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I. DARWIN AND PANGENESIS.

It is nearly ten years since the most important work on biological science which has ever been published, namely, the 'Origin of Species,' issued from the press; and during the long interval, interrupted, we regret to say, by bodily illness, the well-known author of that work has been accumulating further evidence in favour of his theory, which he now gives to the world. So far, his detailed information relates almost entirely to animals and plants under domestication;[*] and although the work in which it is contained forms a continuation of the argument in favour of the derivative origin of species, it does not conclude the consideration of the subject; and we are promised, first, a work upon the variability of organic beings in a state of nature; secondly, one upon the difficulties opposed to the theory of natural selection; and, finally, one in which it is apparently intended by the author to give a *résumé* of the whole subject, and wherein he will "try the principle of natural selection, by seeing how far it will give a fair explanation of the several classes of facts alluded to."[†] We confess that these announcements have taken us a little by surprise; for seeing that the esteemed author of these works, extant and promised, is already about sixty years of age, and that ten years have elapsed between the appearance of his introductory treatise and the one now before us, which is by no means the most important of the series, he must have sufficient faith in his own theory of the "survival of the fittest" to anticipate the extension of his brilliant career to at least the age of ninety. All we can say is, that we hope his expectations may be realized, and that the accumulation of knowledge and thought in the meantime may enable him to bequeath to mankind a biological theory which shall bear the test of future ages, and firmly secure the pedestal of fame upon which the reputation of its author is already elevated.

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[*] 'The Variation of Animals and Plants under Domestication.' By Charles Darwin, M.A., F.R.S., &c. In two vols., with illustrations. Murray, 1868.

[†] Ibid., vol. i., p. 9.

It may be within the memory of some of our readers, that about six years after the appearance of the 'Origin of Species'—when, therefore, sufficient time had elapsed to enable all classes of thinkers to express their views upon the Darwinian theory—we ventured to review the state of scientific opinion upon the subject, and to add such original thoughts as that review had suggested to us;* and as we find in the work before us many attempts to explain difficulties which at that time appeared to us to militate against the unqualified acceptance of the Darwinian doctrine, we may be pardoned for once more touching upon them, with a view to consider whether those obstacles have been removed in the present work, or whether they still impart to the hypothesis an imperfection which needs to be supplied before it can be converted into a well-acknowledged biological guide for all ages.

It appeared to us at that time, as it has to many others, that the author claimed for what he terms "natural selection," powers to modify old species as well as render permanent the character of new ones,—thus implying intelligence and every other attribute requisite for that purpose; and we sought to show that the author himself had not formed a clear conception of what "natural selection" is able to accomplish. We quoted one of his remarks, that "it" (natural selection) "can modify the egg, seed, or young, as easily as the adult;"† but endeavoured to show, by collateral quotations, that the author rather considered the "conditions of life" as the causes which *induce* variability, and that then "natural selection" accumulates those variations when they are profitable for the animal. Now, as by "natural selection" the author meant the part played by nature (the conditions of existence by which the living form is surrounded) analogous to man's operations in selecting and training animals under domestication; so, just as we might say of any change in the nature of an animal, "fattening" or "crossing" has effected it, instead of "the breeder has effected it by fattening or crossing;" we must not be too nice in our distinction of terms, and we must regard "Nature," the "conditions of existence," "natural selection," as in so far one and the same great power favouring the continued existence of certain types, and even in some degree modifying those types, just as the breeder modifies his domesticated animals. But even granting to the author the utmost licence in the use of terms, we could not then, and cannot now, help being drawn insensibly to the conclusion that the *departure* from any existing type results in the main from a change in the reproductive organs of the animal; and it appears to us that whilst in his earlier work the author laid too little stress upon this obscure phase of his subject, it has haunted him throughout the present work; and though he still attributes to the external conditions of existence the chief influence in modifying species (or even varieties), we find his expressions much more clear concerning the agency which immediately operates to bring about this modification, for he says:—"The causes which induce variability act on the mature organism, on the embryo, and, as we have good reason to believe, on both sexual elements before impregnation has been effected."*

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* "Darwin and his Teachings:" 'Quarterly Journal of Science,' April, 1866.

† 'Origin of Species,' 3rd edition (1861), p. 144, par. 2.

Now this is what may be called a much clearer declaration of principle than we have hitherto had from the author; and, leaving out of sight the question of the amount of variability which can by any means be brought about, we find that virtually, according to his views, the nature of the living form is decided at its very conception. For, whether the most widely diverging characters have been secured, as in the author's favourite illustration, the pigeon, or some "spontaneous" variation has sprung up, or some peculiarity has been lost sight of for one or more generations and has suddenly reappeared, in every case, and especially in the latter, the reproductive elements, or one of them, must, according to the author's views, have been the acting or perpetuating agency. In order to account for this marvellous property of the germ, the author has supplied us with a provisional hypothesis, "pangenesis," and has sought to explain how the sexual elements operate upon the fabric of which they serve as the basis. But there still remains a wide subject untouched; and that is, whether and in what degree the reproductive organs are affected by certain psychical causes, with which neither "conditions of existence" nor yet "natural selection" have any immediate relation.

This phase of the question must, however, be left for a moment unconsidered; and having referred to the crucial difficulty upon which we stumble when we regard the mode in which variation *begins*, we must next touch upon that other perplexing problem, hybridism, which is considered by the author's opponents to denote its limits, and to stand as an insuperable obstacle in the way of the acceptance of his theory. In our former notice of the author's works referred to above, we ventured to express the view that the phenomenon of hybridism should be regarded in the light of an occasional check placed by Providence upon the too rapid tendency to vary, which might arise even under the author's slow process, and might cause a reversion to the original stock, or a confusion of forms, totally subversive of all order in animated nature; and although such a view may be seized upon by the opponents of the theory as an admission that there *is* a limit to variation, and that therefore no new species can thus have been brought into existence (a corollary which by no means results from our proposition), yet we find that in the work before us the author quite concurs with our views, excepting that he seeks to explain how hybridism is affected by nature, whilst we contented ourselves with suggesting that Providence does bring about such results, without as yet seeing clearly by what means they are effected. He first compares the phenomena relating to this subject in domesticated animals with those in a state of nature:—"On the principle which makes it necessary for man, whilst he is selecting and improving his domestic varieties, to keep them separate, it would clearly be advantageous to varieties in a state of nature, that is, to incipient species, if they could be kept from blending, either through sexual aversion or by becoming mutually sterile. Hence it at one time appeared to me probable, as it has to others, that this sterility might have been acquired through natural selection. On this point we must suppose that a shade of lessened fertility first *spontaneously appeared*, like any other modification, in certain individuals of a species when crossed with other individuals of the same species, and that successive degrees of infertility, from being advantageous, were slowly accumulated." *

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* 'Animals and Plants under Domestication,' vol. ii., p. 270.

The words italicized by us show that the author had thus only removed the difficulty a little farther from view than before, but he has now come to the conclusion that "species have not been rendered mutually infertile through the accumulative action of natural selection;" . . . "that they have not been endowed through an act of creation with this quality;" but that "it has arisen incidentally during their slow formation in connection with other and *unknown* changes in their organization." † The word (again underlined by us) would lead one to think that the difficulty remains to the author pretty much where it was; but the context shows that he attributes the changes in the reproductive system leading to hybridism to a correlative variation in the whole living form, that is, that when the whole fabric changes, that portion of it which perpetuates the animal changes also, and the ultimate agency is again "pangenesis;" but then again he says, "Pangenesis does not throw much light on hybridism." ‡

There is another view taken by the author, of the occurrence and effect of hybridism in nature, which deserves mention. He finds that when wild animals are at first domesticated, the sudden change in the surrounding conditions of their life renders them for a time infertile: "numerous facts," he says, "have been given, showing that when animals are first subjected to captivity, even in their native land, and although allowed much liberty, their reproductive functions are often greatly impaired or quite annulled;" * but, on the other hand, crosses between varieties slightly modified render the offspring rather more fertile than otherwise. Now he believes that what occurs under domestication by a leap, is slowly proceeding in nature; for *natura non facit saltum*, and that infertility has been gradually proceeding from changed conditions of existence, extending over long ages, but resulting at length in as marked a difference as when the conditions have been suddenly changed from freedom to captivity.

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* 'Animals and Plants under Domestication,' vol. ii., p. 185.

† Ibid., p. 188.

‡ Ibid., p. 385.

But here, again, whilst the author's results appear to be correctly stated, the parallel by which he seeks to explain the cause is unfortunate and inapplicable; for in the case of domestication a male and female *of the same variety* (or one of them) are suddenly rendered quite infertile, their "fertility becomes at once quite annulled;" whereas in nature the individuals of the same species remain quite fertile, *inter se*, whilst it is only when they come to be crossed with other species that the union is barren.

But there is still another aspect of the question, in which a simple statement of facts alone gives to the theory of modification a large amount of weight.

In seeking to show that the barrier of hybridism is not so formidable as his antagonists would make it appear, the author says:

"The sterility of distinct species when first united, and that of their hybrid offspring, graduates by an almost infinite number of steps, from zero, when the ovule is never impregnated and a seed capsule is never formed, up to complete fertility. We can only escape the conclusion that some species are fully fertile when crossed, by determining to designate as varieties all the forms which are quite fertile. This high degree of fertility is, however, rare. Nevertheless, plants which have been exposed to unnatural conditions sometimes become modified in so peculiar a manner that they are much more fertile when crossed by a distinct species than when fertilized by their own pollen. Success in effecting a first union between species and the fertility of their hybrids depends in an eminent degree on the conditions of life being favourable. The innate sterility of hybrids of the same parentage and raised from the same seed-capsule often differs much in degree." †

In our notice of the author's former work we charged him with making light of the difficulties of hybridism. The fact is, he was already in possession of a mass of information which justified his giving less weight to that phase of the question than we were disposed to do, for, in common with many other critics, we had been taught to believe that "species" means two distinct types whose union is infertile. But whatever may be urged against the author's speculations upon the *causes* of certain natural phenomena, no one who knows anything of his character as an observer and writer will receive his statements of facts otherwise than with the most implicit confidence.

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* 'Animals and Plants under Domestication,' vol. ii., p. 176

† Ibid., p. 179.

And now in regard to this apparently insurmountable difficulty of hybridism, the author tells us that, as a rule, "species," that is, widely diverging types, are infertile with each other, but that there are not only cases where they are fertile, but as we descend in the scale of nature, the crossing of species under certain conditions actually increases fertility, and that the only escape from making this admission in many cases, is by reasoning in a circle and calling species varieties because they *are* fertile. Well, as we do believe the author's statements of facts, and as we consider the terms "variety," "species," "genus," &c., to have been introduced into natural history by man for the guidance of his own limited intellect, and to have no actual existence in nature, we are unable to find any rational objection to the broad principle laid down by the author and his predecessors holding similar views, that all new forms of life are and have been modified descendants of pre-existing ones. Nor have we ever been able to see any other rational mode of accounting for the progression of nature. It is, indeed, quite proper at all times that new philosophical theories should be received with "philosophical caution;" it is perfectly just that persons who hold opinions which have been accepted as truths in the past, should require of those who desire to convert them to a new philosophical faith, a large amount of trustworthy evidence in its favour, and should insist upon the clearing away of patent obstacles to its acceptance; but, adopting one of the ordinary principles of jurisprudence, when such an amount of evidence *has* been advanced, and when obstacles which were previously deemed insurmountable have been shown not to be so, the onus of proof then falls upon those who have held the original faith, which may have been conceived in ignorance, and perpetuated by unreasoning philosophical conservatism.

The facts contained in the work before us already show that great modifications in osteological and external structure, and great divergences in habit, may in a brief period be brought about by the changed conditions and artificial selection practised under domestication. These modifications are so great, that were it not for the fertility of the varieties when crossed, no naturalist would hesitate to class them as distinct species. It is also proved almost to a certainty that many domesticated "breeds" which are fertile when intercrossed have descended from ancestors of different species.

Again, a glance at the history of the past shows us that step by step new and more completely organized forms have been superseding old and (in one sense) less perfect ones. Where links have been missing one day, they have been discovered the next. Gaps which appeared insurmountable are constantly being bridged over by the discovery of organic remains, notwithstanding that a great portion of these are still concealed from human research. The growth of the individual is completely typical of what the advocates of descent by modification maintain to have been the history of animated nature.

All these facts are strongly in favour of the theory of the formation of new species by modified descent, and what evidence have the advocates of the opposite theory to advance in its favour? Indeed, it is difficult to find out what their theory really is, or rather what their theories are, for it would hardly be possible to find half-a-dozen anti-Darwinians who, if they think at all, think alike.

Leaving out of the question the means by which the modifications have been brought about, but not doubting for an instant that it has been by slow gradation and natural agencies, and without any derangement of the laws of nature as generally accepted by mankind, we conceive that at least sufficient valid evidence has now been laid before the scientific world to justify its acceptance, pure and simple, of the law of descent by modification, from the operation of which law there is no reason whatever to exclude Man; and all unbiassed thinkers will now expect from the opponents of that theory that they will desist from attacking the new and rational doctrine with absurd theological denunciations, or with quibbles concerning the precise nature of the zoological term "species," but that they will put forward a clear defence of some definite doctrine of their own; will explain with ordinary clearness how they believe new types really have been introduced, and will support their defence by well-established scientific data.

We all know how easy and convenient it is to dash off an article upon such a work as the one before us, in which the world is informed in two or three columns of pompous common-places, that the reviewer sees no new proof of the author's theory, and that until such proofs are forthcoming, it must continue to be regarded as "purely hypothetical;" in other words, that persons who have no inclination to believe it, may reject it until the critic does see some convincing proof of its validity; and of course it is much easier, and, in a reviewing sense, pays much better to make such an announcement a week after the volumes have appeared (which have employed ten years of the author's life), than if the criticism be reserved for even a fortnight's perusal and consideration. It is equally facile, in these days of free-thought, for a person whose biological doctrines have been imbibed from the first chapter of Genesis, and some elementary work on Natural History, to triumph over an unfortunate "Darwinian" by daring him to admit that he believes a Christian and a bull to have had the same ancestry!

But with the exception of a few thinking observers—the measure of whose information is only exceeded by their caution, which prevents them from accepting the new theory—the large majority of its opponents are really such reasoners as we have described; and it appears to us that the acceptance of the theory will depend more upon the decline of superstition than upon the ascendancy of knowledge.

To return, however, to our difficulties. Another feature in the theory of modification of species which presents evidence for as well as against the doctrine of "natural selection" is the inheritance of peculiarities.

In his 'Origin of Species'* the author said:—"The laws governing inheritance are quite unknown: no one can say why a peculiarity in different individuals of the same species, or in individuals of different species, is sometimes inherited and sometimes not so, why the child often reverts in certain characters to its grandfather or grandmother, or more remote ancestor." But as we stated in our criticism already referred to, this very ignorance of the causes of inheritance presents a grave obstacle to acceptance of the doctrine of modification through the external conditions of life; for what can that power have effected "where the deceased *father* is resembled by a posthumous child?"† Had such inherited peculiarities been mental only, they might have resulted from early training; but if we take a case which is not unusual, that the grandchild by a *daughter* of the grandfather resembles the latter both in features and character, then we have the mental and physical peculiarities of a male transmitted through two females, the mother and daughter.

The mode in which we sought to explain such a wonderful phenomenon, and one, as it appeared to us, then at variance with the author's views, was that "from the very commencement of life up to the present hour there are evidences of an *immediate* designing power"—or, to use a term which is looked upon with disfavour by many Darwinians, an *ordaining* power—an occult influence in the production and modification of the sexual elements, and consequently of the beings springing from them, totally distinct from the "conditions of existence," "natural selection," or whatever the force may be called which influences the embryo and the born creature.‡ The justification we have for quoting these few expressions of our own, is that to a large extent the author seems to have adopted the suggestions we then made; and he seeks now to show what that "occult influence" is which modifies the male and female elements of reproduction. Without losing his hold upon the "conditions of existence" which, as we have shown, he considers to be one of the main causes of change in the organs of reproduction, he finds in "pangenesis" the solution of the problem and the immediate means by which the change is effected.

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* P. 13, 8th edition.

† "Darwin and his Teachings:" 'Journal of Science,' vol. iii., p. 174.

‡ Ibid., p. 174.

And now for his provisional hypothesis of "pangenesis." To explain it in his own words, it "implies that the whole organization in the sense of every atom or unit reproduces itself. Hence ovules and pollen-grains—the fertilized seed or egg, as well as buds—include and consist of a multitude of germs thrown off from each separate atom of the organism."

In short, it is the application of the atomic theory to living forms; is in perfect conformity with all the teachings of correlation between vital and physical forces, and as a *provisional hypothesis*, is well worthy of the consideration which the author and others have bestowed upon it.*

The author believes (at least as far as we can judge from his remarks on such an obscure subject) that all changes in the various organisms which result from the contact of the spermatozoon and ovum, as well as those which are derived from gemmation or budding, have their origin in the nature of the *cells* which constitute the elements or materials in operation. The cells or units which constitute all living bodies, from the simplest to the most complex, are themselves organized, and consist of lesser cells or atoms having various natures, and according to the author they give off those constituent atoms as "gemmules," and the nature of those atoms or "gemmules" fixes the future character of the organism into which they enter.

In this manner he seeks to account for the first variation in living types; for the transmission of inherited peculiarities from a grandfather, say, through a daughter to a grandchild; for hybridism. Let us endeavour to explain briefly and as popularly as possible, how the author believes that pangenesis acts in these cases. It must be presumed, first, that the male and female elements each contain a due proportion of cells composed of "gemmules." If there is a preponderance of certain gemmules in the paternal element of reproduction over those of the female, then the offspring may either resemble the father in the next generation, or the effect, being one of quantity, may be latent in that generation and only appear in the succeeding one—the peculiarity being transmitted through the reproductive organs of the intermediate generation which showed no such peculiarity. If the preponderance (the

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* An able article on the subject, called "Cell Life," by Dr. Fick, of Zurich, will be found in this Journal, April, 1866.

"prepotency," as he terms it) be with the mother or female parent, then her or, if a plant, its likeness will be transmitted.

Now, if we once admit, what is of course quite a matter of speculation, namely, that the male and female elements are built up of atoms possessing different properties, bone-forming atoms, flesh-forming atoms, fat-forming atoms, to speak popularly, it is natural to suppose that these atoms when they are distributed through the organism may have an attraction for their kind, and this the author also assumes, and as a consequence that if there be a variation in the constitution of the reproductive elements, there will be a *tendency to vary* in the whole organism, and thus new varieties may arise.

But, finally, if one or both of the sexual elements should be deficient in those gemmules, or in the kind of gemmules necessary for fertilization of some particular form, so that one or both, instead of being "prepotent," should be "impotent," then hybridity is the result—that is, the male of one may be impotent with the female of another species, or *vice versâ*; or they may be mutually infertile.

Some of our readers will probably have felt a little difficulty in following us through this intricate "provisional hypothesis," for it removes still farther from the reach of our senses the agencies by which vital changes are supposed by the author to be brought about in animated nature. That naturalists will have to devote their attention to this obscure question is, however, quite certain; but the large majority of readers, even those tolerably well acquainted with biological phenomena, will only see in the "provisional hypothesis" a means of solving a difficult problem by another still more difficult of solution.

First, let us confine ourselves to the physical aspect of the question. Perhaps the simplest form of cell known to us is the *Amœba.* This consists of cell-contents probably enclosed in a highly elastic cell-wall. The cell-contents comprise a nucleus or germ, a nucleolus within the nucleus, and a number of granules floating in a semi-fluid substance often called "sarcode." This simple cell is already believed to possess in its nucleus and nucleolus some kind of organs of reproduction; but according to the author, it must contain a vast number of gemmules of different natures, for it is from such cells as these, in all probability, that many higher organisms have been built up. It does not necessarily follow that such a cell should contain "gemmules" of all kinds needful for the assimilation of the various organic and inorganic substances with which higher organisms that will proceed from it "by descent" are to be nourished; but what the cell must at some time or other have (according to the author's views) is a tendency to vary, else we should come to a standstill at the very threshold of "nature's progression," and all the beautiful varieties of infusoria, even, would have remained still in the conception of the Maker.

Now what perplexes us is, how in this humble form the surrounding conditions of external nature can operate to bring about a "tendency to vary." To say that we are unable to understand this, and the less therefore we say about it the better—as the author occasionally does when he comes to a dead-lock in some mystery of nature—is taking refuge behind even less defensible breastworks than those of his opponents; for they have at least a Divine force and Will to appeal to on all such occasions. The author says, at the conclusion of his chapter on "pangenesis:"—"Finally, the power of propagation possessed by each separate cell, using the term in its largest sense, determines the reproduction, the variability, the development, and renovation of each living organism." (But, we would ask parenthetically, how does that cell itself begin to vary?) "No other attempt has been made, imperfect as this confessedly is, to connect under one point of view these several grand classes of facts. We cannot fathom the marvellous complexity of an organic being; but, on the hypothesis here advanced, this complexity is much increased. Each living creature must be looked at as a microcosm—a little universe formed of a host of self-propagating organisms, inconceivably minute, and as numerous as the stars in the heaven."

In regard to the latter portion of this paragraph, we cordially award to the able author the credit of having exhibited and illustrated the theory of cell-life, in a manner so novel and interesting as to take it out of the mere province of speculation, and to present it as one well deserving of the earnest consideration of biologists. The application of its principles to the phenomena of the hereditary transmission of peculiarities, whether they be normal or abnormal, such as the inheritance of peculiar features or of special diseases, opens out a wide field for research, and ere long the physical aspect of many of those phenomena may be made clear; but when he treats living "gemmules" as he would atoms of inorganic matter which go to form crystals, and seeks to clear up the difficulties accompanying the first tendency to vary by resorting to this almost unconsidered theory to account for the defects in his own well-founded hypothesis, we have an exhibition of weakness rather than an addition of strength.

Just let us examine one or two of his examples of the operation of pangenesis.

The author finds that when animals are suddenly brought under domestication, they are for a time infertile, and, as it has already been shown, this infertility is compared with that which gradually supervenes as varieties become more divergent in Nature.

Now, it is quite possible that in both these cases the number of the hypothetical "gemmules" in the spermatozoon or ovule may be deficient or their nature defective; but has it yet been shown that in the instance first named there is any spermatozoon at all in existence? Would it not be more philosophical to ascertain first whether the material element is present or absent (we of course refer to the higher animals, in which the phenomenon of hybridism comes out most prominently) before we attempt to discuss the number or nature of its constituents, of which we at present know nothing?

Or in these same cases of hybridism induced by sudden captivity, or by divergence in nature, we would ask the author, Are the periodical movements and the affinities of the sexual elements already so well understood that it should be safe to pass them by and descend to the consideration of the probable effect of their hypothetical invisible constituents?

But, on the other hand, there can be no doubt that when the male and female elements are perfect and perform their proper functions, they do possess powers which exceed in strangeness anything that the most fertile imagination has yet invented. Just imagine a man with a finger wanting on one hand, and one or more of his children being born with the same defect! It is just within the range of possibility that the state of mind of the mother may by some mysterious influence have caused that defect to be reproduced; but looking at all similar phenomena, it is far more probable that the defect has been communicated by the paternal male element to the ovum, and thus perpetuated in the embryo.

Let us now, however, turn for a moment to the psychical phenomena which present themselves when we consider the tendency of living types to vary, and the occasional checks which are put upon their divergence, and we shall find the cell-theory as little able to account for those as we should find a musical instrument capable of conveying an explanation of the passions which its notes inspire in the human breast, and which nerve the arm of the warrior, exhausted by a weary march, or lull to rest the spirit of a fretful child.

The author, as we have seen, admits that the reproductive elements constitute that portion of the organism in or through which the tendency to vary probably first manifests itself, but (if we understand him correctly) he attributes the change in those elements to altered physical conditions alone. Now, if we pass in review before our mind's eye the various types of animals which must have succeeded each other through modified descent, we find that amongst the lower forms it is just possible to conceive that the tendency to variation in the reproductive elements might be the result of external physical influences alone; but this admission would of itself be fatal to the application of the same theory to the higher animals, whose tendency to vary (we do not speak of any special organs) depends palpably to a large extent upon the action of mental influences. An *Actinia may* find itself surrounded by natural conditions over which it has no control, as changed food, deficiency or superabundance of light, or any other physical cause, and which may bring about a change in its reproductive elements, and thus give rise to a new variety. But would it be either natural or rational to apply this rule to the higher animals, especially to Man? Is it not certain that there we have psychical forces inducing actions, and those actions bringing about new varieties, and in a manner independently of those material influences which operate lower down in the animal scale.

A union may be brought about between two human beings solely from the attractions of the mind; and let us suppose some marked *mental* quality to be inherited. Now, we are apt to use the term "inherited" somewhat arbitrarily; for what appears to be thus communicated might, after all, be the result of mental training or example, which would have operated in a foster-child as well as in true offspring, and in that case the illustration would cease to hold good. But assuming that there is a "prepotency" on the side of the father to transmit his likeness, and that therefore some slight cerebral characteristic descends to the son, upon whom training and example are brought to bear, so that the mental quality, whatever it may be, comes to be developed in a higher degree in the son than in the father.

Here we have two distinct states of facts and two forces: the one physical, the other psychical; the one material, and explicable only upon a "provisional hypothesis," the other metaphysical, and yet as clear and patent as any such matters can be to the human mind.

In the parents, love or respect operating, it is true, through the senses, but uninfluenced by the "sense" in a lower acceptation of the term, brings about a union which is to lead to a new variation both in the physical and psychical nature of man. In the offspring, solicitude evinced in training or teaching, that is, mental intercommunication, and *later on the unfettered will of the offspring,* develop and perpetuate the mental quality, and almost certainly mould the brain and physical frame in conformity to the new condition: the immaterial, impalpable soul acts, invisibly to us, upon the brain, just as we develop the muscles through physical exercise; but prominent before all other phenomena we find the *will*, the *soul*, the active, guiding, moving force at work, and at work upon willing, passive materials.

Now look at the materialistic hypothesis. We will admit that it is possible a "prepotency" in the father may have given his likeness to the son: that the supposed order, number, nature, and disposition of the supposed gemmules in the male organ may have been the first cause of this transmission. We admit that surrounding physical conditions, such as like food, climate, and habits, may have had some share in moulding the physical frame as it became developed. We will even, for argument's sake, admit the cellular hypothesis in its most materialistic form, and suppose that the little, hypothetical, invisible, vitalized atoms are themselves the *seat* of all those qualities which accumulate as they (the atoms) accumulate; and that they are the motive power instead of the mere instruments upon which the psychical forces act. But are not these very admissions,—does not this very process of reasoning, with all its hypotheses and its uncertainties, sink back into ridiculous improbability before the clear, unmistakable operation of the psychical forces upon the subservient vegetative system—a system complex, indeed, as the author declares it to be, but complex only in the same sense as a musical instrument is so whilst it stands silently and unconsciously awaiting the touch of the master-hand, impelled by the master-spirit?

Nor is the comparison between Nature and Art in this case so entirely figurative as it would appear at first sight. The musical instrument has no power of growth, but the most we can say of nature, or "Natural Selection," in moulding man, is that it is the unconscious agent, like the artizan who collects and selects the materials and builds them up, little dreaming of the heavenly music which will be extracted from them. Then comes the skilful tuner, Man, who, under the tuition of his Creator, brings the mental chords into harmony; and finally the freed Soul, acting independently, wakes the fabric into active life, as the inspired musician wakes the mute instrument into melodious strains; but, in every case, in nature as in art, who doubts that an intelligent designing Mind is in constant operation?

That the author doubts the constant interposition of a designing Mind in nature is clear from his concluding remarks; and in order to render him justice, we will extract those remarks in full, for it will be seen how thoroughly ungenerous, or how utterly ignorant are those who brand his theory as Atheistical, and him as an Atheist, whilst at the same time it will exhibit the feebleness of that reasoning which has led him and some few of his disciples to disbelieve in the immediate and constant interposition of Providence in the development of the universe.

"Some authors have declared that Natural Selection explains nothing, unless the precise cause of each individual difference be made clear. Now, if it were explained to a savage utterly ignorant of the art of building, how the edifice had been raised stone upon stone, and why wedge-formed fragments were used for the arches, flat stones for the roofs, &c.; and if the use of each part and of the whole building were pointed out, it would be unreasonable if he declared that nothing had been made clear to him, because the precise cause of the shape of each fragment could not be given. But this is a nearly parallel case with the objection that selection explains nothing because we know not the cause of each individual difference in the structure of each being.

"The shape of the fragments of stone at the base of our precipice may be called accidental, but this is not strictly correct; for the shape of each depends on a long sequence of events, all obeying natural laws; on the nature of the rock, on the lines of deposition or cleavage, on the form of the mountain, which depends on its upheaval and subsequent denudation, and lastly on the storm or earthquake which threw down the fragments. But in regard to the use to which the fragments may be put, their shape may be strictly said to be accidental. And here we are led to face a great difficulty, in alluding to which I am aware that I am travelling beyond my proper province. An omniscient Creator must have foreseen every consequence which results from the laws imposed by Him. But can it be reasonably maintained that the Creator intentionally ordered, if we use the words in an ordinary sense, that certain fragments of rock should assume certain shapes so that the builder might erect his edifice? If the various laws which have determined the shape of each fragment were not predetermined for the builder's sake, can it with any greater probability be maintained that He specially ordained for the sake of the breeder each of the innumerable variations in our domestic animals and plants;—many of these variations being of no service to man, and not beneficial—far more often injurious—to the creatures themselves? Did He ordain that the crop and tail-feathers of the pigeon should vary in order that the fancier might make his grotesque pouter and fantail breeds? Did He cause the frame and mental qualities of the dog to vary in order that a breed might be formed of indomitable ferocity, with jaws fitted to pin down the bull for man's brutal sport? But if we give up the principle in one case,—if we do not admit that the variations of the primeval dog were intentionally guided, in order that the greyhound, for instance, that perfect image of symmetry and vigour, might be formed,—no shadow of reason can be assigned for the belief that variations alike in nature and the result of the same general laws, which have been the groundwork through natural selection of the formation of the most perfectly adapted animals in the world, man included, were intentionally and specially guided. However much we may wish it, we can hardly follow Professor Asa Gray in his belief that 'variation has been led along certain beneficial lines,' like a stream 'along definite and useful lines of irrigation.' If we assume that each particular variation was from the beginning of all time pre-ordained, the plasticity of organization, which leads to many injurious deviations of structure, as well as that redundant power of reproduction which inevitably leads to a struggle for existence, and as a consequence to the natural selection or survival of the fittest, must appear to us superfluous laws of nature. On the other hand, an omnipotent and omniscient Creator ordains everything and foresees everything. Thus we are brought face to face with a difficulty as insoluble as is that of free-will and predestination."*

Here we have an illustrated confession of faith (if it can be so called), which is well deserving of consideration.

Truly, those who say that "natural selection" explains nothing, because the author of the theory does not attempt to "make clear the precise cause of each individual difference," are unreasonable; but were we to accept the simile of the temple built of stones which have fallen from the heights, "natural selection" would avail nothing for the author of the '*Origin* of Species.' If, conforming to his wish expressed here, but certainly not elsewhere in his works, we simply accept the law of selection as accounting for the uses to which the stones have been applied in the building of the temple, what have we gained in knowledge of the causes or forces which led to the shape of the stones? In other words, "natural selection" has been in operation for the purpose of *preserving* the fittest varieties, whether new "species" arose through modified descent or whether they were special creations. All the author shows by his simile is that an intelligent mind has selected and preserved the most fitting varieties or types, as the builder selected the stones best adapted for his purpose, a proposition which, we need hardly tell our readers, we are quite prepared to admit. But the author is not satisfied with attributing to physical causes the selection and retention of fitting types; he tries to find in those causes alone the springs of variation.†

And, to pass on now to the remaining portion of the paragraphs which we have extracted: he believes furthermore that, popularly and generally speaking, all those variations have been accidental, and not pre-ordained; although, in conclusion, he confesses that the omnipotence and omniscience of the Creator "ordains everything and foresees everything;" and so the author does not exactly know what to believe. But his grounds for not believing that variations were pre-ordained and pre-designed, if we may use the term, are the strangest we have ever read.

"Do you imagine," he says, "that God made the wild dog plastic and variable in its nature, that man might select and perpetuate a ferocious type to pander to his cruel taste of bull-fighting?"

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* 'Animals and Plants under Domestication,' vol. ii., pp. 430–2.

† See 'Animals and Plants under Domestication,' chap. xxii. (especially the Summary on "Causes of Variability," and the whole chapter on "Pangenesis").

"Certainly not," is supposed to be our answer.

"Then," says the author triumphantly, "you must at the same time admit that this plasticity and law of natural selection could not have been pre-ordained for the purpose of producing the most symmetrical and perfect of dogs, the greyhound; and now, if the law did not contemplate the formation of the ugly and useless, nor yet that of the symmetrical and vigorous, it could not have contemplated anything at all, and all the results found in nature are accidental, so to speak!"

Does the author forget that Man has a free-will and the power to control nature as well as God? and that in his folly, fancy, or caprice, he often misapplies materials and misdirects natural forces for his own selfish ends? And are we on that account to close our eyes to every manifestation of design, arrangement, and co-ordination which presents itself in nature, and to say that the abuse shall explain the use, the exception shall constitute the rule? Shall we measure God's wisdom by our folly? His knowledge by our ignorance?

But the author has sufficiently pointed out elsewhere in his work, that "nature" has modified living types with purposes widely different from those of man, namely, for the benefit of the creature itself. "What does the breeder care," he says,* "about any slight change in the molar teeth of his pigs, or for an additional molar tooth in the dog, or for any change in the intestinal canal, or other internal organ? The breeder cares for the flesh of his cattle being well marbled with fat, and for an accumulation of fat within the abdomen of his sheep, and this he has effected." "Natural species, on the other hand, have been modified exclusively for their own good, to fit them for infinitely diversified conditions of life," &c.†

What would the author say if we adopted his method of reasoning thus:—"The plasticity of the ox was not designed with a view to its being fattened for man's use: this application was an accidental one. In like manner, and with still greater force, it may be added that the refuse of oil seeds, known as cattle-cake, has been accidentally applied to the fattening of the ox, for the husk and exhausted tissue were designed for a different purpose." And so the whole scheme of Providence would vanish, and natural forces, divinely and designedly guided, would give place to a beautiful, well-regulated, co-ordinated *chapter of accidents!!*

All he proves by his reasoning is that whilst our knowledge and power over nature are limited, those of God are unlimited; that whilst God operates for the benefit of all his living creatures, we are too apt to apply our power and knowledge to selfish purposes; and in all probability that, whilst our powers of modifying varieties so as to form new species are limited by restricted information and the brief duration of life, those of the Almighty know no such bounds. Nature is his handiwork; natural forces are his servants; and to Him there is no time, but an eternal "now" for the execution of his wise and infinitely varied schemes.

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* See 'Animals and Plants under Domestication,' p. 412. † Ibid., p. 413.

The author's illustration of the temple built by human hands out of the rough stones of nature, is susceptible of another application besides the one he has given to it. The explanation of the mode in which the stones have been selected is not to be found in the atoms of which they are constituted, nor on the physical forces which have given them their imperfect forms. They have to be made perfect for the end designed, by the intelligently guided hand of the artizan, and to be raised up into a useful and ornamental structure upon the pre-existing plan of the designing architect.

But whilst we are unable to agree with the author in his views as to the first causes of variability, and the operation of that mysterious influence which binds us to nature, and both to God; and whilst we feel that it is for the interest of scientific truth, after which no man seeks more earnestly than the author himself, that we should exhibit the fallacy and unhesitatingly express our disapproval of the line of argument which he adopts in these speculative matters, still we find in the mass of evidence already advanced by him, both designedly, with a view to establish his theory, and unconsciously in his descriptions of natural phenomena, such ample proofs of the production of new species by modified descent, that we are surprised any thinking person should still adhere to a doctrine which has only theological prejudices and long-established ignorance to support it. And as to the provisional hypothesis of "pangenesis," it is theoretically and *materially* consistent with all else that has been recently ascertained in other departments of physical science. Those who have studied natural phenomena with the aid of the microscope must have been satisfied that what we have been in the habit of calling the lowest forms of life are not so in reality; and coupling the appearances revealed by that instrument with the facts disclosed in the animated discussions which have from time to time taken place on the so-called "spontaneous generation," we see in "pangenesis" a probable solution of the difficulty.

But on the other hand, whether these supposed vital atoms vary in their constitution, or whether, resembling each other, they have yet varied powers of assimilating inorganic substances, is a secret which neither the indefatigable and all-observant author, nor any one else, can at present decide; and we must await the perfection of our instruments before we are able even to hazard an opinion in that respect. And furthermore, instead of enabling us to dispense with the theory of an immediate, constant, and designing Providence, this minute subdivision of vitality, so to speak, adds, in our humble opinion, to the necessity for a still more immediate and constant association between the invisible Spirit and his visible Universe. We can conceive of *Man* being entrusted with powers of selecting small differences, and by wise adaptation creating new types; we can conceive of "Nature" influencing the plastic forms of the lower animals, and causing the fittest to survive; but when we descend to cells and gemmules, the very atoms which constitute the unconscious elements of reproduction, we can conceive of no force except the Prime Force which shall determine their nature and operations, and decide what great results shall spring from such insignificant causes.

Of the author's rare merits as an observer; of his undeviating adherence to the truth so far as he can perceive it, and at whatever cost to his feelings; of his bold avowal of his tenets, without regarding the spirit in which they are likely to be received by a half-educated and theologically-prejudiced public, it is unnecessary for us to speak; his works answer for themselves.

Darwin stands side by side with Galileo; he is not only figuratively, but actually, as great a philosopher. Happily in our day retractations can no longer be enforced; and no such mental or bodily sacrifices to the cause of truth are required now as formerly. There may be thousands who, reading by proxy or thinking by substitute, would like to see him incarcerated for blasphemy; but there are myriads of intelligent men, lay as well as clerical, who look forward anxiously to each new revelation of his mind and pen, and love and admire the bold pioneer of truth as though they were his intimate friends and associates. But though Darwin has once more told the world that Nature moves, as Galileo proclaimed that the earth moves, yet he has only partially discovered the secret of its motion; and judging from the persistency with which he seeks in nature only the causes of nature's change (a feeling resulting no doubt from too close observation of details), we believe it is left for some other eye to see the apple fall, and solve the great mystery of vital gravitation. Some day the mind will no doubt visit us which can grasp the whole range of vital phenomena, and at a glance comprehend the action of those mysterious forces which cause physical atoms of like constitution to seek each other amid varying external conditions; the opening flower to follow the sun in its course; which produce the wonderful affinity between the unconscious elements of reproduction; which lead the bird to seek its mate; the weaker mind to lean upon the stronger; the soul to search for, to expand, and to change its own nature by association with its God.

II. GOLD IN CALIFORNIA.

By J. Arthur Phillips.

The principal gold-producing portion of California extends, on the western slope of the Sierra Nevada, from the Téjon Pass to the northern extremity of the state.

The slates of which it is mostly composed have been shown by the officers of the Geological Survey to belong chiefly to the Jurassic period, although the occurrence of Triassic fossils in the auriferous rocks of certain sections of the belt renders it probable that some of the slates in the heart of the gold region belong to that age.

These sedimentary rocks for the most part consist of various slates and schists, more or less metamorphosed, and sometimes containing nodules of feldspar; sandstones are also frequently met with, and these are often transformed into quartzites. Black talcose schists with slates, exhibiting a well-defined cleavage, together with bands of more or less crystalline limestone, also occur.

Lying between the band of metamorphic slates and the great granitic mass of which the Sierra Nevada principally consists, are found various crystalline rocks, such as syenites and porphyries. All of these rocks in the vicinity of the sedimentary deposits enclose numerous veins of quartz which contain, in addition to gold, iron pyrites, and other metallic sulphides. The quartz veins of the crystalline rocks are comprised within a narrow zone, extending from south to north, along the western flank of the Sierra, above the band of auriferous slates, and are found, in the vicinity of the line of junction, throughout nearly its whole extent.

The veins of the metamorphosed slates occupy a lower position on the western slope of the range, and are exceedingly numerous and important. They are not, however, by any means equally distributed throughout the region of slates, but are, for the most part, concentrated in a belt having a width, from east to west, of about fifteen miles, and extending from south to north throughout the length of the formation. They in general follow the direction of the strata in which they are enclosed, but this parallelism is seldom absolute; besides which they frequently throw off branches and offsets, cutting through the bedding of the slates at very considerable angles.

It is also to be remarked that wherever the slates have been tilted so that the bedding has become almost perpendicular, and where they have generally been subjected to the largest amount of metamorphic action, the veins are usually most productive. In fact, although there are exceptions to the rule, gold veins enclosed in stratified rocks are generally productive in proportion to the amount of metamorphic action to which the enclosing strata have been subjected.

The matrix of the auriferous veins of California is invariably quartz, which is usually crystalline, and, in the majority of cases, is ribboned in such a way as to form a succession of layers parallel with the enclosing walls. In some cases these parellel bands are separated from each other by a layer of quartz, differing slightly, either in colour or structure, from that forming the seams themselves; whilst in others they can only be distinguished by the difference of colour of two adjoining members of the series.

In many instances, however, laminæ of the enclosing slates divide the vein into distinct bands, and in such cases the thickness of the interposed fragments is often not greater than that of writing-paper.

In addition to ordinary quartz, amorphous silica, or semi-opal, and chalcedony are sometimes met with; and this opal, which is interfoliated between the layers of true quartz, occasionally contains iron pyrites and metallic gold. The walls are in most instances smooth, and often afford evidence of a considerable amount of mechanical action, whilst between them and the vein itself a thin stratum of clay or *flucan* is sometimes interposed.

In some of the detrital deposits of the gold regions distinctly marked quartz veins are observed cutting through the gravels, and are evidently formed by the action of water holding silica in solution. In certain localities also bands of silicious slates are found to contain small quantities of gold.

Analysis has shown that the quartz constituting the matrix of the auriferous veins of California almost invariably gives off, on being heated to redness, a certain amount of water which is not eliminated by a prolonged exposure to a temperature of 212° F., and that, in addition to alumina, oxide of iron, and other impurities, it always contains minute quantities of potash. On being reduced to the state of thin sections, for the purpose of examination under the microscope, the quartz is found to contain numerous small cavities partially filled with a liquid in which vacuities or gas-bubbles are seen to move about with great facility.

Boiling and hot springs are exceedingly numerous throughout California and the adjoining state of Nevada; and in Steamboat Valley, about seven miles from Virginia city, a large quartz vein appears to be now in process of formation by hydrothermal agencies. The hot springs of this locality are situated at a height of 5,000 feet above the level of the sea, on the eastern declivity of the Sierra, and the granitic rock here presents several straight and parallel fissures, either giving exit to heated water, or simply ejecting steam. The first group of openings comprises five longitudinal crevices extending in a straight line, and parallel to each other, for a distance of over 3,000 feet. These fissures are separated from one another by intervals of from 40 to 60 feet, have each a width of about 12 inches, and are connected with each other by lesser openings, intersecting the first nearly at right angles to their direction. All these crevices are usually full of boiling water, which overflows and escapes in the form of a rivulet; at other times it does not flow over, although violent ebullition may be heard to be taking place at a short distance below the surface. All these fissures have become partially filled by a silicious deposit which is being constantly increased by the formation of new layers on the sides, whilst a longitudinal central crevice allows of the escape of boiling water and steam. On the most western of these lines of fracture are several centres of active eruption, from which boiling water is sometimes ejected, by the action of steam, to a height of from 8 to 10 feet. These waters are alkaline, and contain, in addition to carbonate of soda, the sulphate of that base, and chloride of sodium. There is also a considerable escape of carbonic acid and sulphuretted hydrogen; these products give rise to the deposition, near the surface, of sulphur and anhydrous oxide of iron.

To the west of those above described, another fissure, having the same origin, is observed, but this is no longer traversed by currents of hot water, although at various points throughout its extent it still gives off steam and carbonic acid. At its northern extremity a central fissure remains open, but in other localities it is, for the most part, closed by an accumulation of silicious concretions.

The total distance over which this deposit can be traced is considerably more than a mile. The deposits of Steamboat Springs are, to a certain extent, metalliferous, and, in addition to oxide of iron, they contain oxide of manganese, together with iron and copper pyrites. M. Laur, a French mining engineer, deputed by the Imperial Government to examine and report on the mineral resources of the Pacific coast, states that they also contain gold.

Another remarkable example of the recent deposition of minerals is to be found in the vicinity of the celebrated Borax Lake, where solfatara action is still vigorous, and a large amount of sulphur has accumulated. This deposit is known as the "Sulphur Bank," and covers an area of some six or seven acres in extent. It consists of a much decomposed volcanic rock, traversed by innumerable fissures, through which steam and various gases are continually issuing, and over and through which large quantities of sulphur have been deposited, in such a way that at first sight the whole appears to consist of a mass of this substance. This sulphur is being constantly deposited, its deposition being attended by the evolution of aqueous vapour and carbonic and boracic acids, but it apparently takes place without the emission of sulphuretted hydrogen. The gaseous matters issuing from the crevices in the rock have usually a temperature of about 95° F., and appears to have been the agency by which the various mineral substances formed in the cavities were brought to the surface. Sulphur is being constantly deposited on the surfaces of the various fissures, and is sometimes mixed with cinnabar, although more frequently with pulverulent silica, often blackened by the presence of a tarry hydro-carbon. With these traces of gold and silver are stated to sometimes occur.

On the sides of the various fissures, gelatinous silica is found coating chalcedony, in various stages of induration, from a pasty condition, to that of the hardest opal: cinnabar is also found in thin bands, and occasionally even in veins of considerable thickness. Where the bituminous matter before referred to occurs in the largest quantities, the mass becomes black and friable, the cinnabar in such cases being replaced by metallic mercury.

In another locality of the same character, about ten miles distant, a vein of compact silicious rock, about ten inches in thickness and evidently of very recent origin, yielded by assay silver to the value of nearly three pounds per ton, together with traces of gold.

The above and other similar facts appear to lead to the conclusion that auriferous quartz veins are the result of aqueous agencies, and that their mineral and metallic constituents have, as well as their silicious matrix, been deposited from solution.

The extraction of auriferous quartz from the veins in which it occurs is conducted in precisely the same way that the mining of tin and copper ores is carried on in this and other European countries, and some of the workings have already reached considerable depths. Among the deepest mines in the state is Hayward's, in Amador County. This has now reached a depth of more than 1,300 feet on the inclination of the vein, and is, at the present time, more profitable to the proprietors than at any former period. The amount of veinstone annually raised is usually about 90,000 tons, and the yield of gold, on an average, from fourteen to eighteen pennyweights per ton. It may be here remarked that the productiveness of the quartz veins of California has not been found, as was at one time prognosticated, to decrease in depth; but that, on the contrary, many mines which were, near the surface, comparatively unproductive, have materially improved as lower levels are attained. It is also a fact worthy of notice, that all remuneratively auriferous gold veins contain notable quantities of iron pyrites and other metallic sulphides, and that the association of these minerals with gold is so constant, and so remarkable, as to be, in all probability, the result of some chemical action regulating the distribution of the precious metal.

The constant presence of iron pyrites in auriferous veins, and, whenever so occurring, its invariably enclosing a certain amount of gold, suggest the probability of this sulphide being, in some way, necessarily connected with the solvent by which the precious metal was held in solution. In the present state of our knowledge of this subject, it would be impossible to explain the exact process by which the solution of gold was effected. It has, however, been shown by Wurtz, that finely divided gold is soluble in sesquichloride of iron, and, more sparingly, in the sesquisulphate of that metal. It is also well known that iron pyrites, sometimes at least, result from the action of reducing agents on the sulphates of that metal. If therefore a sulphate of iron, in a solution containing gold, should become transformed by the action of a reducing agent into pyrites, the gold, at the same time, being reduced to the metallic state, would probably be found enclosed in the resulting crystals of that mineral.

On being brought to the surface the auriferous rock is first passed through a Blake's crusher, or is broken into fragments of a suitable weight, by the use of heavy hammers, and then reduced to the state of a very fine sand, under the pestles of a stamping mill. This machine differs from that employed in Cornwall for the treatment of tin ores, in so much as the heads and lifters, or "stems," are both invariably of iron, and of a cylindrical form, whilst the cams are arranged around a heavy wrought-iron shaft in such a way as to cause them to be raised in regular succession, giving to each, at the same time, a rotary motion. The "battery boxes," or "cofers," are also formed of a single iron casting, and movable "dies" are so placed along its bottom as to correspond with the "shoes" which form the wearing surfaces of the pestles. These *shoes* and *dies* possess the advantage of being readily changed when worn out, and the motion of rotation before referred to has the effect of keeping the faces constantly even. These machines, which instead of being driven by toothed gearing are worked by means of broad indiarubber belts, are fed by a shovel through a long slot at the back of each battery box.

In some cases a little quicksilver is, at regular intervals, dropped into the battery, but in others no mercury is used under the pestles, and the pulverized rock is simply washed by a stream of water, which is admitted into the arrangement by ordinary gas-pipes, through fine gratings in front of each cofer, and over a series of blankets covering the inside surfaces of wooden troughs inclined at a slight angle with the horizon.

These blankets are frequently removed for the purpose of being washed in large tanks, in which the auriferous matter accumulates, and from whence it is subsequently removed to be passed through an amalgamator. In order that there should be no interruption in the continuous action of the machinery, two of these blanket-troughs are laid down before each battery, so that when the blankets from one of them are being washed, the stream of water and sand issuing from the mill is conducted over the other.

Beyond the blankets are troughs lined with amalgamated sheet-copper, to retain any light particles of gold that might otherwise escape; these again terminate in settling-pits, or tyes, in which a portion of the sand and the greater part of the auriferous pyrites are collected.

The gold and other heavy materials collected in the vats in which the blanket-washing is carried on, are afterwards passed through the amalgamator. This machine consists of two wooden rollers, about eight inches in diameter and two feet in length, furnished, on their circumference, with knife-bladed pieces of iron arranged around them with their edges at right angles to the cylinders, and working in cisterns containing mercury. Above these rollers, which are set in motion by belts, both in the same direction, but contrary to the course of the water flowing through the apparatus, is a hopper for receiving the sand to be washed. Below the cylinder is a "riffle-board," having an inclination of about seven degrees from the horizontal, and generally covered by plates of amalgamated copper, which can be readily slipped out for the purpose of having the gold amalgam which may have become attached to them scraped off. When copper plates are not employed for this purpose, the transverse grooves of the riffles are charged with mercury. To use this apparatus some of the sand, taken from the cisterns in which the blankets have been washed, is placed in the hopper, and a small stream of slightly warm water allowed to play on it, in such a way as to gradually wash it under the revolving spiked cylinders, and from thence over the amalgamated riffles. The riffle-board is usually nine feet in length, is divided by ribs into several channels, and has, at its lower extremity, a cistern for retaining the pyrites, which, not combining with mercury, escapes amalgamation.

The sulphides thus collected are sometimes ground with mercury in a small arrastre, or edge-mill, and, after extracting from them as much gold as can be thus obtained, they may, if they still retain a sufficient amount of the precious metal, be drawn off, and, after settling, be collected and sold for treatment by chlorination, or smelting with lead ore.

The quicksilver drawn off from the amalgamator is first strained, either through close canvas or buckskin, the solid amalgam is distilled in a cast-iron retort, and the gold fused in blacklead crucibles, and then cast into ingots.

The auriferous pyrites is concentrated by washing, and when the chlorination process is employed, it is subsequently roasted "dead" in a reverberatory furnace, and afterwards subjected, in a moist state, to the action of chlorine gas. Chloride of gold is subsequently washed out with hot water, the gold precipitated by sulphate of iron, and then run into bars in the usual way.

The present average cost of treating gold quartz in California is estimated to be about as follows—

	s.	d.
In Water Mills, water free, per ton of 2,000 lbs.	4	10
„ „ „ water purchased	6	6
„ Steam „ „ „	8	7

Although a very large amount of the gold annually collected in California was doubtless originally derived from the disintegration of auriferous veins, not more than one-third of the precious metal now annually brought into the market is procured from that source. The other two-thirds is derived from alluvial diggings, in which it is separated by washing from the clay, sand, and gravel with which it is associated.

These gold-bearing drifts belong to at least two distinct geological epochs, both comparatively modern, although the later period is distinctly separated from the former; its materials being chiefly derived from the recent disintegration and re-distribution of the materials of the older.

The more ancient deposits are in all probability referable to a river-system different from that which now exists, flowing at a higher level, or over a less elevated continent and not unfrequently nearly at right angles to the main valleys of the present period. In many localities the older deposits, or "deep placers," are covered by a thick capping of lava, and in some places this eruptive matter occurs in the form of basaltic columns, beneath which are found the layers of sand, gravel, and boulders with which gold is associated.

In many localities, and particularly between the middle and south forks of the Yuba river, these auriferous gravels have, where exposed to denudation, a thickness of 120 feet; and of more than 250 feet where they have been protected by a volcanic capping. These vast auriferous beds are composed of rounded masses of all the crystalline and metamorphic rocks which occur above them in the Sierra. As a general rule, the lower portions are composed of larger boulders than the upper, although large rounded water-worn masses of rock occasionally make their appearance among the middle and upper members of the series; water-worn gold is more or less disseminated throughout the whole mass of these deposits, although not with equal uniformity, but always in greater abundance in the immediate vicinity of the "bed-rock." The materials of which these deep deposits are composed are frequently consolidated into a sort of hard concrete, by being firmly bound together by crystalline iron pyrites, and sometimes this cementing material partially consists of carbonate of lime and amorphous silica. The wood which occurs in these deep gravel beds is either beautifully silicified or is replaced by iron pyrites. In such localities a piece of wood will frequently be met with, of which one end had been converted into lignite, whilst the other remained unaltered, but the whole having subsequently become silicified, now presents the appearance of a combination of alabaster and black marble, each portion distinctly retaining the structure of the original wood.

The assay of specimens of the cementing pyrites shows that it invariably contains small, but very variable quantities of gold. In order to ascertain whether this exists in the form of water-worn grains, mechanically enclosed within the crystals of sulphide, or in the shape of crystals or spongy and filamentary particles, similar to those met with in the pyrites of auriferous veins, numerous fragments were attacked by nitric acid, and the residue subsequently subjected to microscopical examination.

In this way granules of the precious metal were detected which had evidently been worn by the action of running water, whilst others appeared not to have been subjected to such attrition. With regard to similar deposits in Australia, Mr. Ulrich* remarks, "In the gold-drifts (Ballarat, Daylesford, Clunes leads, Loddon River, alluvium near Vaughan, &c.) pyrites is often found encrusting or entirely replacing roots and driftwood; such specimens very quickly decompose on exposure to the atmosphere, and samples have, on assay by Messrs. Daintree, Latta, and Newbery, likewise yielded from a few pennyweights to several ounces of gold per ton. According to Mr. H. A. Thompson, a beautiful specimen of crystallized iron pyrites deposited on a piece of wood taken from the drift immediately below the basalt, at Ballarat, gave, by assay, 40 ounces of gold per ton, and in another case, where only the pyrites from the centre of an old tree-trunk was examined, the yield was over 30 dwts. of gold per ton. Some of the fine dust obtained by washing out the gold at the Royal Saxon claim, Ballarat, yielded, by assay, over 15 oz. of gold per ton. When placed under the microscope, this dust was seen to be composed of minute crystals of pyrites aggregated into round pellets, from 1-300th to 1-100th of an inch in diameter, the surface being roughened by the projecting angles of the crystals and un-water-worn."

The amount of skill and capital necessary for the successful prosecution of gold washing or placer mining is usually less than is requisite for carrying on quartz mining on a remunerative scale. Water is the great agent, by the aid of which placer mining is carried on; with a large supply the operations of the miner can be cheaply and rapidly conducted, but without it, or with only a limited supply, a claim that would otherwise have been highly remunerative, may either become valueless, or be only capable of affording very irregular returns.

Placer mines are of two distinct kinds, shallow and deep; shallow or surface diggings are generally found in the beds of ravines or gullies, on the bars and in the beds of modern rivers, and in shallow flats; in the latter, as before stated, the pay-dirt is often at great depths from the surface, and not unfrequently covered by thick beds of lava or volcanic ash.

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* 'Notes on the Physical Geography, Geology, and Mineralogy of Victoria.' By Alfred R. C. Selwyn and George H. T. Ulrich, p. 56. Melbourne: 1866.

The appliances made use of in the shallow diggings are usually very simple, such as the pan, rocker, long-tom, and sluice, whilst for the deeper deposits hydraulic mining is now generally resorted to.

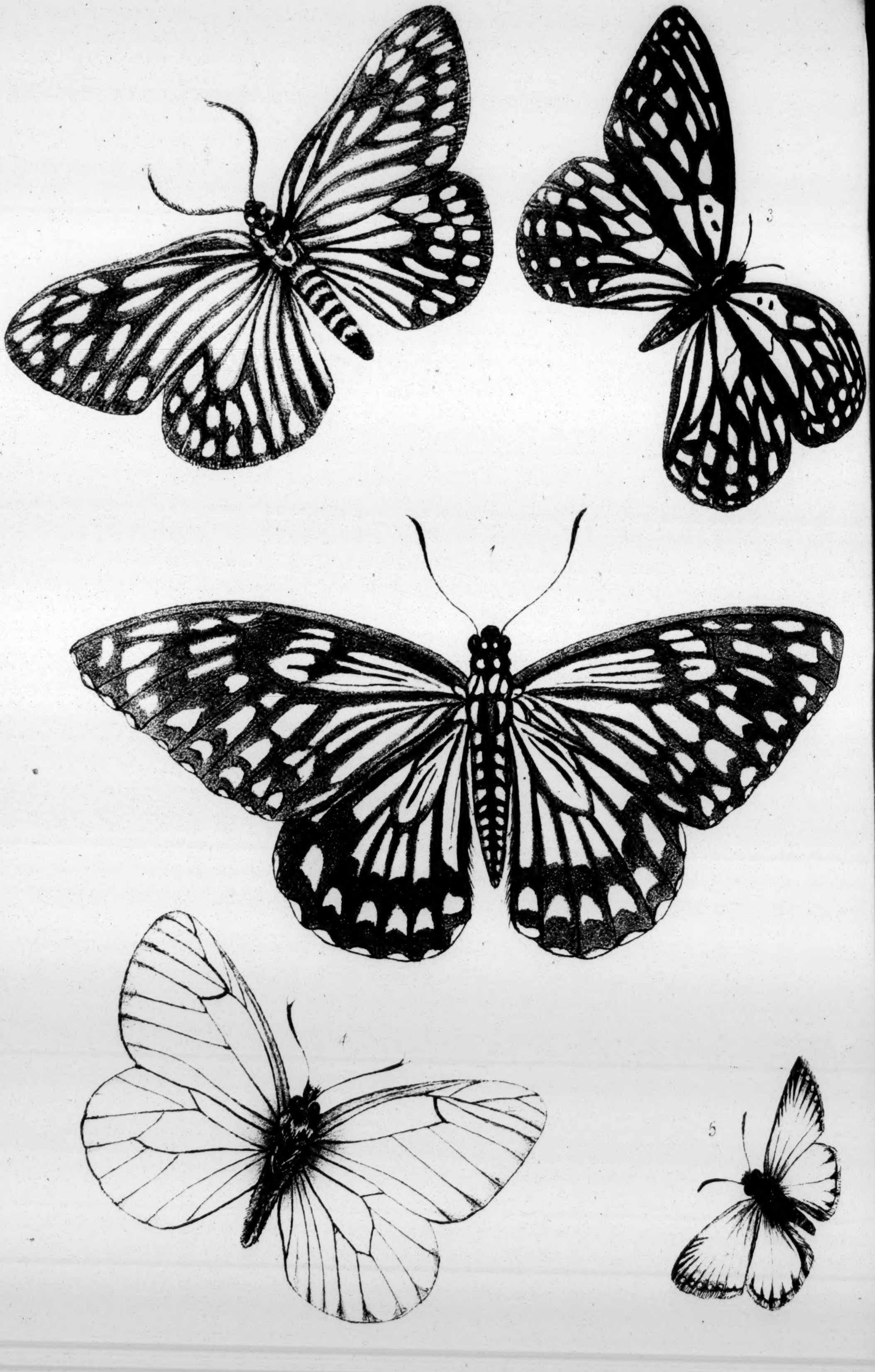
Among the most remarkable objects that first strike the attention of the visitor to the mining regions of California, are the lofty aqueducts constructed of trestle work for conveying water across valleys and ravines. These, and the various canals with which they are connected, are usually the property of companies who supply the miners, whose claims lie along their course, with the amount of water they may require, charging for it at rates varying from a shilling to five pence per miner's inch. The miner's inch is usually reckoned as the amount of water which will flow through a hole of an inch square, under a mean head of six inches, during ten hours.

In hydraulic mining the water from a canal is brought, by side flumes or aqueducts, to the head of the ground, with an elevation of from 120 to 150 feet, where it is conducted into a wooden box into which it constantly flows. This is provided with a valve, and from it the water is conveyed to the bottom of the claim by means of a strong sheet-iron pipe. At the lower extremity of this is a thick cast-iron chamber, in the sides of which are apertures, provided with slide-valves, to which flexible hose, terminating in bronze nozzles, can be attached by means of union joints. Jets of water are directed from these against the bank, by which means it becomes rapidly disintegrated and washed down through a sluice, in which are wooden or stone riffles charged with mercury, with which the gold becomes amalgamated and is thus retained.

The illustration shows the method of conducting the operations of hydraulic mining. Some tail-sluices employed for this purpose are as much as from fifteen to twenty feet in width, and several hundred yards in length. The more ordinary width of a hydraulic sluice is, however, from four to eight feet. When it is desired to collect the gold, the sluice is cleaned up, the mercury strained, and the amalgam retorted. To give an idea of the amount of work done in a hydraulic claim in the course of twenty-four hours, it may be mentioned that 350 miner's inches of water, with a head of 160 feet, will remove and wash above 4,000 tons of gravel per diem, leaving a small profit on the working of stuff affording gold to the value of only three half-pence per ton. Some of the aqueducts are carried across valleys at a height of 125 feet, and the aggregate length of the different ditches belonging to the Eureka Company alone exceeds 200 miles.

The largest yield of gold during any one year was in 1853,

Page 324



J. Erxleben lith.
M & N Hanhart imp.

1. PAPILIO Zacreus? PAPILIONIDÆ. | 2. CYCLOSIA Papilionaris, HETEROCERA.
3. CRINOMA Damaris, SATYRIDÆ. | 4. PIERIS Cratæci PIERIDÆ.
5 PYRCUS Arsalte, HESPERIDÆ.

when it amounted to 15,000,000*l.* sterling, since which period the production of California has steadily declined, and the present annual return of the precious metal does not much exceed 5,300,000*l.*

The total value of the gold produced in the state, from the time of the discovery of that metal in 1848 to the close of 1866, is estimated at 167,260,000*l.*

III. ON THE COLOUR-PATTERNS OF BUTTERFLIES.

By Rev. H. H. Higgins, M.A.

The petals of flowers, the plumage of birds, the surfaces of shells, the hides of quadrupeds, the integuments of polyps, and the wings of insects, are some of the chief objects distinguished by a great variety of natural colour-patterns.

All that I propose to attempt in the present instance is to offer a few remarks on the proximate origin and general configuration of the patches, bands, and spots of colour which adorn the wings of the Rhopalocera.

By the use of the term "proximate origin," the inquiry is limited to the appliances immediately engaged in producing the results under consideration; an inquiry which cannot conveniently be separated from the question, whether amidst the apparently capricious and endless varieties of colour-patterns on the wings of butterflies, may be recognized the elements of a prevailing arrangement.

An example of the kind of agency contemplated may be found in the serrated edge of the leaf of a Potentilla, which, it is said, is the result of a certain configuration of organs discernible in the leaf-bud; or, again, the spines on the shell of a Murex, which may be shown to be the result of tentacular appendages periodically developed in the mollusc.

The physical conditions which have preceded so delicate a result as the shading of the colours on the wing of a butterfly, require a kind of investigation which must be attended with corresponding difficulties. But it will be admitted that in no case is a spot or a band added or obliterated except through the instrumentality of antecedents sufficient to produce the result in question. How far these antecedents are capable of being investigated has yet to be determined.

The rudiments of wings, according to Burmeister, may be observed when the caterpillar has completed its third moulting and has attained its full size. "They at first present themselves as short viscous leaves, the substance of which greatly resembles that of the mucous tunic, and to which many delicate tracheæ pass which distribute themselves throughout them."

The wings in an imperfect condition, whilst still enclosed by the shell of the chrysalis, are closely folded together with many plications. Can any clue to the subsequent arrangement of the colours be found in the manner in which the wings are folded in the pupa state? If a scrawl of any kind be made on paper with a pen, and if the paper be folded, the ink being inside and still wet, a symmetrical pattern is produced, the sides of which, like the markings on the wings of a butterfly, exactly correspond. And it is manifest that under certain conditions of folding, colouring matter of any kind might, by a comparatively simple process of arrangement, produce patterns remarkable for symmetry and regularity.

In the limited number of instances in which I have been able to examine the sufficiently advanced chrysalis of a butterfly, nothing of this kind has been indicated: the like spots on the right and left wings do not, in the pupa state, coincide; the folds do not bisect the markings; that which becomes a beautifully formed band, begins as a mere line, or a shapeless spot; and this stage of the metamorphosis, if watched, conveys a decided impression that the resulting colour-pattern is not dependent on the folding of the wings in the immature condition.

The perfect wing of a Lepidopterous insect consists of a delicate double membrane, traversed between the folds by nerves or veins ramifying from the base. The wings are covered with minute scales of various shapes and colours, which, in combination, form a pattern much after the manner of the materials used by an artist in constructing a piece of mosaic work.

Three elements then are essential to the wing, the double membrane, the veins, and the scales covering both.

The simplest type of colour presents itself in the plain uniform tint, exhibited when the scales are all exactly alike. Examples of this are rare in nature. A variety of *Pieris rapæ* is almost wholly white; *Gonepteryx rhamni* is almost wholly yellow.

It seems probable, however, that the scales growing on the membrane upon or near the veins would be distinguished from the scales growing on other parts of the membrane by a freer development of pigmentary matter, and that in this manner would arise a kind of primary or fundamental pattern, namely, a pale ground with darker linear markings following the course of the veins, *e.g.* *Pieris cratægi*.

For the present we shall notice only the upper surface of the wings, in which the prevalence of the primary pattern is more clearly indicated.

Most butterflies exhibit some traces of the *black-veined white* pattern; and the pattern itself, with slight modifications, is found in species belonging to eight of the fourteen families into which the butterflies are divided.* (See Plate.)

The fundamental character of this dark-veined pattern is confirmed by the closeness of the gradations connecting it with others apparently altogether distinct. For example, *Pieris brassicæ*, and some other insects of the same family, which are wholly white with the exception of a broad black tip at the apex of the fore-wing. Now several exotic species of *Pieris* present the dark veins expanded at the outer margin of the fore-wing into a deeply scalloped black border; others show the gradual fading of the lower portions of the border, together with attenuation of the venous markings in the disc of the wing, till the passage from the pattern of *P. cratægi* to that of *P. brassicæ* is made by almost imperceptible steps.

In the genus *Hestia*, the primary pattern is diversified by a great variety of black spots and blotches, which are all evidently dependent on the venation: the spots occupy a central position between the veins, or they are bisected by a false vein, or they are in pairs contiguous to a vein. In one fine species there is a broad, black band across the wing; but here (as in almost every other instance) the outlines of the black markings are strongly affected by the veins. We shall see, presently, that this is not the case with the brighter colours; but the black markings are very generally thrown nearer to or farther from the base by the passage of a vein, as geological strata are disturbed by the occurrence of a fault. Even where, as in *Euplæa Treitschkei*, only a small spot or two of white is shown on the wings, it is pretty plain that the ground-colour of the wings is white, almost wholly obscured by a greater development of the dark scales belonging to the veins.

The scalloped border has been referred to; and as the scalloped band, nearer to or farther from the margin of the wing, is one of the most prevalent kinds of markings, it may be well to see how readily it may arise from the primary pattern. Let it be supposed that at a given distance from the base a portion of the dark scales begin to diverge on each side from the veins. The dark lines thus formed will meet in the middle of the areas between the veins, producing a band of scallops having their concavities towards the base of the wing. If the divergence takes place towards the base, scallops are formed having their convexities in the same direction. If the latter mode of divergence be quickly followed by the former, a row of annular markings between the veins is the result. In this manner may be obtained the simplest and most elementary form of the annular or ocellate spot, which in the higher stages of development becomes distinguished for its variety and exquisite beauty. Of this, more hereafter.

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* Even in the less likely families, *Nymphalidæ* and *Satyridæ*, it occurs in *Penthema Lisarda*, *Orinoma Damaris*, and other species.

Before leaving the subject of the dark vein scales, it may be desirable again to refer to the folding of the wings in the pupa state; for although the pattern is not supposed to be the result of the plications, yet the compressed condition of every part of the wing, whilst in the chrysalis, must be borne in mind. The divergence of a portion of the vein scales to form scallops is difficult to be conceived if we regard the process as wrought in the fully expanded wing; but the whole scallop is a microscopic speck, and the direction of the divergence quite indistinguishable in the pupa state. Yet in this state, whilst the vessels are soft and permeable, the scheme of the future pattern is, no doubt, fully organized, so that the most minute extension this way or that from the incipient vein, of the dark pigment bearing germs of scales, when inflated, expanded, dried and hardened in the wing of the imago, becomes a band, or a scallop, or a ring, according to the original construction and direction.

From the vein scales, then, are supposed to arise all the darker markings which limit and sometimes enclose the areas occupied by the paler ground-tint; frequently, in fact, extending over the greater portion of the surface of the wing. These darker markings are manifestly affected by the passage of the veins, and very commonly, though not always, are distinguished by an outline more or less sharp and distinct.

We come now to inquire into the modifications observable in the paler ground-colour, proper to the scales growing on the spaces between the veins, and often extending over the veins themselves. The first and most obvious modification is the deepening or intensifying of the colour in certain parts of the wing: thus, yellow becomes bright orange; white becomes yellow or scarlet; a pale buff becomes bright testaceous, &c. The transition is generally gradual, the richer being shaded off at its edges into the paler colour. Indeed, so characteristic of the ground-pattern is this kind of shading, that I propose to call the area occupied by the brighter and more intense hue, the "blush." A very satisfactory example of the blush is seen in *Gonepteryx Cleopatra*.

Belonging essentially to the membranous portions of the wing, the blush should not in its contour be affected by the veins, and for the most part it seems to be remarkably independent of them. It occurs in all parts of the wing, at the tip or in the disc, at the margin or, less frequently, near the base, often at the anal angle of the hind wing; but wherever it occurs, it seems to be neither limited nor extended by the veins. It is of course liable, like the ground-colour to which it belongs, to be parted into bands or spots by the dark vein scales; in fact, the whole area of the blush is seldom seen, and more frequently than otherwise the junction of the blush with the pale tint, or rather the space where the junction might have been, is occupied by expanded parts of the black venous pattern.

The blush is not always shaded at its junction with the paler tint, especially where it takes the form of a patch or a spot; as in the tip of the fore-wing of the male of *Anthocharis Cardamines*, the spot in the fore-wing of *Gonepteryx Rhamni*, and that on the anal angle of the hind-wing of *Papilio Machaon*.

In *Vanessa Cardui* the blush is suffused over the greater part of the fore and hind wings, the pale ground colour appearing in spots towards the tip of the fore-wing, on the under side of which the "blush" character of the rose-tint is more plainly exhibited.

In *Vanessa Atalanta* a similar disposition of colours is observable, but the black vein-scales cover a larger portion of the wings, the bright scarlet of the blush being shown in a band on the fore-wing and on the margin of the hind-wing.*

The shading of the paler into the brighter hue is well seen in *Vanessa Urticæ*.

The testaceous colour of the *Fritillaries* I am inclined to regard as a blush, uniformly suffused over the whole area of the wings. The dependence of the black scales on the veins is seen throughout the tribe.

In *Papilio Hector* the blush is exhibited in the crimson spots on the hind wings.

In *Thais Rumina* the blush is broken up into spots, but it will be observed that the crimson spots have black edges, and are rarely bordered by the yellow ground-colour.

We have now observed three important elements in the colour patterns of butterflies: the pale ground-colour; the dark markings due to the vein scales; and the more or less richly-tinted blush; a fourth remains to be noticed.

Hitherto, the scales themselves have presented no very marked distinctions; the black scales, colour excepted, are in appearance exactly similar to the adjacent white or red ones. Under a magnifying power and by transmitted light, all are found to contain appropriate colouring matter; thus, an orange band is made up of orange-coloured scales, and a black marking of dark and nearly opaque scales.

But conspicuous on the wings of butterflies are certain other hues, and these the most splendid of any, which when examined by transmitted light are found to be produced by scales not of corresponding colours. *Lycæna Adonis*, the most brilliant of the British "Blues," has scales altogether colourless; the deep purple on the wings of *Apatura Iris* is produced by scales the colouring matter of which is brownish black. A similar hue on *Thecla Quercus* is formed by scales the colour of a dark cloud. The brightest scales on *Lycæna Phleas* are of a watery burnt-sienna hue. Far more striking discrepancies between the transmitted and reflected hues of scales might be quoted from exotic butterflies: I have selected these because the insects are more familiarly known. Viewed as opaque objects, even under a moderately high magnifying power, at the proper angle the reflected hue comes out superbly, but when the light is sent through the scales, a pale, or dull dark tint is all that is observable.

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* That the scarlet band is a blush, shown as it were through an opening in the black scales, appears from the under-side of the fore-wing. This is seen still more plainly in the allied species *Pyrameis Gonerilla* from New Zealand.

These scales therefore exhibit the phenomena of iridescence, and their hues are derived, not from the colouring matter present in them, but from striations upon their surfaces; not, however, from the striæ which under a microscope may be seen on all Lepidopterous scales, but from others far more minute, surpassing, probably, in delicacy and uniformity, anything elsewhere to be found in nature. The surfaces of iridescent bodies, such as mother-of-pearl and some of the ores of iron and copper are often very gorgeously tinted, but their hues are mixed and irregular, whereas nothing can exceed the purity of colour exhibited by patches of these iridescent scales, indicating a wondrous exactness in the intervals between the striæ.

For convenience, I shall call the feature produced in the colour-pattern by these iridescent scales, the "gloss."

The gloss seems to have towards the dark vein scales the same kind of relation which the blush has towards the pale ground-colour, except that it seems to be rather charged upon, than shaded off into, the venous scales, being sometimes, as it were, sprinkled or dusted upon them, as in *Papilio Paris* and *Teinopalpus imperialis.*

The gloss is rarely seen to form sharply-defined bands or patches, nor does it often come in contact with the ground-colour or the blush, being almost always surrounded by a black border: it frequently suffuses the whole wing,* and is often pierced by the black vein scales, which show themselves as spots in the midst of it.

In rare instances, highly-coloured scales, belonging to the blush, exhibit iridescence; when this occurs the result is exquisitely beautiful. Thus, in *Papilio Vertumnus,* a patch of carmine scales on the hind-wing is glossed so as to show an amethystine hue when seen obliquely; and in one rare species of *Ornithoptera* the yellow patch on the hind-wing has similar reflections. In these butterflies the carmine and yellow hues are the results of corresponding pigment granules; the amethystine gloss arising from iridescent striæ on the surfaces of the scales which contain the pigment grains.

It is a source of much gratification in all branches of natural history, to observe the modifications of an organ through a series of species, in one or other of which it may become so changed in appearance, that its identification is possible only by a close comparison between the many links which connect its most abnormal forms with those in which it is ordinarily found.

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* As in some *Morphos* and many of the *Lycænidæ.*

I have often felt the want of a *rationale* of this kind, in admiring the colour-patterns of butterflies, and have endeavoured to trace a kind of homology between their respective constituents.

For a long time the case seemed hopeless; but opportunities having been afforded me of examining a moderately large number of *Rhopalocera* from most parts of the world where they abound, many apparent anomalies were found to be so only because intermediate forms had not previously been known to me. Thus, for instance, I have ventured to speak of the red spot at the anal angle of the hind-wing of our British Swallow-tailed Butterfly as a form of the "blush." British butterflies alone considered, this must appear to be simply fanciful; but any one who will examine even a limited number of species of the large genus *Papilio* will, I think, be satisfied that the red spot on the hind wing of *P. Machaon* is a modification of the richer tinting of the pale ground-colour, such as may be seen in its more ordinary form in *P. Zagreus* (Doubleday), and in a striking intermediate form in *P. Iswara* (White).

I have only touched on the elementary portion of the subject; more minute details must be reserved for another occasion; but I venture to hope that the present very imperfect account of an attempt to classify the colour-patterns of butterflies may not be uninteresting to their admirers, and may lead to further investigations by more able observers.

IV. THE MODERN ASPECTS OF PHYSICAL SCIENCE.

If we examine with thoughtful deliberation the aspects of Physical Science as they are now presented to our mental vision, we arrive at the conclusion that much uncertainty surrounds them, and we feel that with the advance of knowledge we shall have to modify many a pet hypothesis and, possibly, to abandon some favourite theories which have held their position by the weight of the great names by which they have been supported.

We have before us ten works, each one of them excellent in its class,* and in their entirety fairly representing the conditions of the

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* 1. 'The Elements of Natural Philosophy; or, an Introduction to the Study of the Physical Sciences.' By Charles Brooke, M.A., M.B., F.R.S. Churchill.

2. 'Heat considered as a Mode of Motion.' By John Tyndall, F.R.S. Longmans.

3. 'Faraday as a Discoverer.' By John Tyndall. Longmans.

Physical Science of the present day; and it is from a careful study of those, that we arrive at the conclusion that the present is a transition period. We have included in our list some recent works on Chemistry. When the reader reflects on the phenomena connected with the so-called molecular forces—embracing especially those of capillary attraction, of exosmose and endosmose, of epipolic action or surface force, of all that belongs to the allotropic state, and of the facts connected with diffusion and transpiration—he will feel that Physics claims a large portion of the domain of Chemistry as its own. The influences of Light, Heat, and Electricity, in producing chemical changes, and again the development of those energies by chemical action, prove the close alliance of Physical and Chemical Science in all that relates to the properties of molecules and masses. It is on this account—although we may not, in this article, make any further reference to them—that we have included Watts's admirable 'Dictionary of Chemistry' and Dr. Hofmann's excellent little volume, as the exponents of the principles—it might be better to write—the philosophy—of this science. Our desire is to stimulate inquiry, to invite search, and to show that amongst the authorities in science there exist great differences of opinion upon some most important questions. Therefore we have selected those works which most fully and satisfactorily set forth the philosophy of modern Physical Science as the basis of our remarks.

It is universally admitted that we live in a transition period. Old things are being roughly examined, and in many cases subverted, while the New is only, as yet, upon trial. As the political atmosphere exhibits unmistakable tendencies towards a storm, all the elements of which are surely gathering upon the horizon, so the philosophical atmosphere is disturbed by the conflict of opposing currents of thought, which threaten a cyclonic movement likely to carry destruction as it passes, through many a favoured field. Some of our social organizations, stamped with the approval of centuries, and which have hitherto been, through the sanctifying powers of age, regarded with feelings of superstitious reverence, are being rudely shaken. It is clear that many of them will perish in the storm; but it is not so clear that those systems which will occupy the ground they filled are destined to endure so long, or to serve

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4. 'The Reign of Law.' By the Duke of Argyll. Strachan.
5. 'A Treatise on Frictional Electricity.' By the late Sir Wm. Snow Harris; edited by Charles Tomlinson, F.R.S. Virtue.
6. 'Researches on Solar Physics.' By Warren De la Rue, F.R.S.; Balfour Stewart, F.R.S.; and Benjamin Loewy. Printed for private circulation.
7. 'A Dictionary of Chemistry.' By Henry Watts, F.R.S., &c. Longmans.
8. 'Introduction to Modern Chemistry, &c.' By A. W. Hofmann, LL.D., F.R.S. Walton & Maberley.
9. 'Reports of the British Association.'
10. 'Philosophical Transactions of the Royal Society.'

so well the purposes for which they are designed—the happiness and peace of men—as those which we are now impulsively rejecting as of an ancient type.

Thus it is, too, in the purer regions of thought. There is an ominous trembling amongst those trees of knowledge which were planted by our truth-seeking forefathers, and which have borne fruit to science. The rustling of the leaves is all that is heard at present; but this indicates too truly a passing undulation of great power, the precursor of a sweeping force, before which all the trees of knowledge must bend, and those which are not securely planted, and of vigorous growth, must fall to rise no more.

Whether the tendencies of the present time are favourable to the production of Truths is a question to which it is not easy to give a satisfactory answer. That throbbing of the brain and pulsation of the heart which mark the movements of the men of to-day, and which manifest themselves in impulsive action and sensational thought, are, we fear, extending themselves with dangerous influences to the philosophers. In many an essay in which questions of pure science are discussed, in books professedly enunciating some high philosophy, and in lectures professing to teach the simple truths which experiments have brought to light, may be discovered the symptoms of that prevailing mental epidemic which is mainly distinguished by a straining after effect, a desire to surprise, and a resolve to be, in one way or another, sensational.

The worth of scientific knowledge is far too commonly estimated according as the men of to-day have fixed upon one or the other of two standards: the first being its money-worth—the commercial value of science in some practical application; and the second, its sensational value—its worth as a surprise to the public mind, or its influence as a lecture experiment which shall, in theatrical phrase, bring down the house.

To borrow the thought—it is not our purpose to quote the exact words—of a living philosopher; man appeared to us a few years since as beginning to consider himself not merely as the denizen but as the interpreter of Nature, and inspired by the noble prospects opening to him, he exhibited a tendency to become a humble but diligent seeker of the means by which to unravel some of the lowest of her mysteries, and catch a dim, because a distant, glimpse of the designs of the Creator. "The cherub Contemplation" appeared to find a genial atmosphere amongst us. With a religious calmness, men asked for more light to guide them in their pursuit of truth. There were many who—regardless of external sympathy, caring but little for applause, unrepressed by difficulty and undisturbed by the excitements of the world—pursued their tranquil paths, earnestly seeking for some development of Nature's mysteries, regarding the discovery of a truth its own exceeding great reward. These men became each the centre of a circle, to the extremity of which they diffused the influences by which they were themselves inspired; and as the Magnet induces in every neighbouring particle of iron its own powers, so the master-minds induced in other minds that love of truth and that desire to know by which they were themselves so nobly stirred.

It is certain that this period of the awakening of the popular mind, which, with human pride, was spoken of as the "March of Intellect" age, was of but brief duration. Either from a want of reality in the professors of this intellectual religion, or from external influences which are so complicated that they almost escape detection, the desire *to learn* was repressed, and in its place appeared the animal craving *to enjoy*.

"And thus it has happened that in so many cases the impulse of intellectual activity even when given has failed of propagation. The ball has not been caught up at the rebound, and urged forward by emulous hands. The march of progress, in place of quickening to a race, has halted in tardy and intermitted steps, and soon ceased altogether."*

It will appear to many that the talk which we have lately heard respecting Technical Education, and the establishment of Science schools, indicates a consciousness of the value of science. It indicates that science has made itself felt as a power in the land; that there is an awakening to the fact that labour may be saved, and the result of labour improved, or, in other words, that money may be made out of it, but nothing more. The teachers of science may become many, and through even imperfect instruments a considerable amount of knowledge may be diffused among the people; but we fear that in all this there is but little prospect of producing cultivators of science. Whenever there has been an increase of schools, there has been a decay of the sciences or arts to which they have been dedicated. The Past tells us this; let us hope that the Future will not find in the Present another example of this. Having indicated the condition of the Sciences (as it appears to us) as an element of knowledge diffused amongst the so-called thinking classes of Europe, we must proceed to our examination of the actual state of scientific knowledge amongst us.

It ever has been, and for a long period of time it must continue to be, that the popular notion of things runs in grooves which have been cut out by some original minds. In the history of the sciences this is seen to have been the case from the earliest recorded period unto the present day. We smile now at the phlogistic theory—a principle of levity is regarded as the unsatisfactory dream of men imperfectly instructed; yet a careful examination of the hypotheses of the present day will convince the examiner that, although they assist us to climb, they are but stepping-stones which will be kicked away as we advance. A careful writer, whose work is now before us, says he cannot doubt that ere long all physical phenomena will be acknowledged to be *the results or effects of various, but interchangeable modifications of Energy;* that is, that Motion, Light, Heat, and Electricity (and, with many, Life) are but the developments of Energy—manifestations of Force. "The term *energy* meaning simply the power of doing work; *force*, meaning the power of producing energy." Let us endeavour to give a faithful example as an illustration of the meaning of this; for the metaphysical refinement which involves this hypothesis hides it, as by a veil, from vulgar intelligences. A mass of gunpowder is a store of *force*, but the force is *potential* only; it is placed in a cannon, with a shot—an inert mass—in front of it, in the tube. A spark is applied, it matters not how, and the force becoming *actual*, imparts energy to the shot, which flies through space and strikes an iron target. The primary Energy—shown in motion—is checked, and we find it is converted into Heat and Light at the moment the blow is given, and, there is but little doubt, also into Electricity.

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* Herschel, "Whewell on the Inductive Sciences:" 'Quarterly Review,' No. 135.

The *force* which was *potential* in the gunpowder, and which was developed, or made *actual*, by the explosion—producing Motion, Heat, Light, and Electricity—is not destroyed; it exists as an Eternal Energy, or, in the poetic phrase of a writer of note, the flash of the pistol fired by a murderer years long ago is being repeated in space, flashing from star to star; and the sigh of the drowning slave will undulate for ever, until, at the last day, it becomes the damning evidence against the slave-dealer.

"The principle of the 'Conservation of Energy' implies that when once actual energy has been developed in matter, it cannot be annihilated; it can only be transferred in some form to other matter. So universal is the truth and practical application of this principle of conservation, that it may almost be taken as an axiom that it is no more the narrowly-bounded power of man to create or annihilate *force* or *energy* than it is to create matter itself: energy may be variously transmuted and directed, and matter may be variously combined and modified in form and physical properties, but that is all."—*Brooke.*

In passing, it is but justice to state that, although we differ widely from Mr. Brooke in many of his conclusions, and fail to see the cogency of several of his arguments, we know of no other work which more clearly places 'The Elements of Natural Philosophy' before the student; and therefore we recommend it to the attention of every one who is desirous of learning the present state of the Physical Sciences, and, indeed, of studying the main features of the philosophy of the inductive sciences,—except chemistry,—in their more important generalities.

We have spoken of the *energy*, or power of doing work, as developed by or from a *force* dormant in the gunpowder. Let us examine this a little further. This combustible substance is a compound of carbon, sulphur, and nitre; and it owes its power (*force*) to the collision of the molecules of the carbon with those of the oxygen concentrated in the nitre. Without involving ourselves in the mysteries of combustion—for we must call them so—we admit that the molecules of carbon and those of oxygen being forced into union, Heat and Light are the result. Did these physical forces exist as positive entities in the carbon or in the nitre, or were they created from the molecules of matter by the act of union? The answer is before us:—"In long bygone ages the energies of solar light and heat were occupied in the development of woody tissue;" and every molecule of wood is such by virtue of the energy which has been expended in producing it. A cube of wood represents an equivalent of solar force, which, as the energies in sunshine, did the work of producing it (*i.e.* of establishing *growth*), and they were "used up" in doing the work. The solar energies were not destroyed, but from an active they changed into a passive state; and the wood is a reservoir of sleeping—dormant power. Thus probably it is with the oxygen of the nitre; but we are not yet in a position to trace out satisfactorily the process of the absorption of solar energy by any inorganic mass. If the magic and the beauty of photographic phenomena had not led men away from the study of the science of the chemical energy of the sun (Actinism) to the production of heliographic pictures, we might possibly have advanced our knowledge in this direction.

In the process of converting the wood into charcoal, there does not appear to be any appreciable loss of its solar energy; therefore the grains of charcoal in the gunpowder are cells of sunshine, and by combustion this is suddenly developed. There is, of course, some solar energy—Heat and Light—lost in the flash of light seen at the mouth of the cannon, but much of it has given motion—energy—to the shot, and sent it forth to do its work of destruction, in which, by the sudden suspension of its *motion*, Heat and Light are again seen ready to do some work somewhere: but we can trace force and energy no further.

To give one other example in illustration of the great prevailing doctrine of our modern philosophers—coal is but changed vegetable matter which grew under the influences of sunshine, myriads of ages ere yet man had being. This substance holds its equivalent of solar energy. It is placed under the boiler of a steam-engine, and combustion is established. The heat passes into the water and it becomes steam. This water-vapour, full of solar energy, produces, by ingenious mechanical contrivances, motion, which is applied in doing work of various kinds. If, however, it is employed in driving round the armatures of electro-magnets, it is *converted*, according to the prevailing hypothesis, into magnetic, and this again into electric energy. "This being transmitted between carbon electrodes, an immense amount of light and heat is produced by molecular friction at the point of great resistance to the passage of the current; and these are produced at the expense of electric energy, as proved by the loss of current. Here, then, we have the final transmutation of electric into thermic and photic energy, the latter being so intense as to have thrown a shadow across the brightest sunbeam, and to produce an amount of illumination unattainable by any other known means."—*Brooke.*

By the "undulatory theory" we believe we explain not only the phenomena of Light but those of Heat and Electricity. With some misgivings we venture to ask, Have we not been advanced to this by a system of reasoning from analogy, and are analogies always to be trusted? Sound, we know, is developed by the vibration of material atoms; where there is matter in a state of extreme attenuation, it is scarcely possible to convey through it any audible sound, and silence reigns supreme in even the imperfect vacuum which we can produce. Since, then, sound is proved to require a medium through which its waves may be propagated, what kind of medium can we imagine to be all diffusive and all penetrating, in which the waves of Light, Heat, and Electricity can be generated, and through which they can be propagated across the immensities of space and amidst the interstices of a material body? The wave motions of Light and Heat are supposed to take place in an infinitely elastic, imperceptible, imponderable medium, which pervades space and fills the interstices between the atoms of matter. This is the "*Ether*" of modern philosophers. Some evidence of the existence of an attenuated medium of some kind, in the stellar regions, is obtained by the observations of the periodic retardation of Encke's comet. Although this has been the received idea since the general adoption of the wave theory, it is now giving place to the hypothesis of the vibratory disturbances of the material atoms themselves; the kind of vibration—motion—determining the kind of physical energy which becomes the object of sensuous perception. This hypothesis is very strongly put before us in "Heat considered as a Mode of Motion;" and in the numerous essays which have within the last few years been given to the world by the philosophers of the metaphysical school, especially such as are tinctured with the German modes of thought. It is not our purpose to accept or reject either hypothesis—they have been, and they may continue to be, useful as hypotheses; but we would not have them advanced to the dignity of theories until all that now appears contradictory or inadequate in them is removed, or by extension placed in a more satisfactory position. That all the physical energies become sensible only when in motion, is an established fact. That Heat may require one mode of motion, and Light another, can scarcely be denied. But we have still to inquire what is it that is moved, and where is the Mover. It is not enough to say it is the Ether that is put into undulation; we cannot rest satisfied with the idea, in many cases much too dogmatically put, that the vibration of material atoms produces, according to its degree, one or the other kind of physical energy. However positively these scientific dogmas may be asserted, it should never be forgotten that they are but hypotheses, and that notwithstanding the appeal which is constantly made to mathematical analysis in support of them, the evidence is yet wanting to establish their first principles. Faraday long since showed us that a dew-drop held within it a quantity of Electricity which would, if suddenly liberated, be sufficient to destroy the life of a small animal. He also proved that this great quantity of electricity was necessary to the combination of the gases, oxygen and hydrogen, into that drop of water. Beyond this, we know that water is the fluid which we find it, by virtue of a given equivalent of heat, and by the simple process of chemical decomposition we may burn this water—strictly, its elements—and produce heat and light of the highest intensity. Are those phenomena explained in any way by the dynamical theory? We think not.

At the same time that we are advancing to those metaphysical conclusions, we find ourselves in blind ignorance respecting the most simple conditions which rule the molecular condition of matter, whether inorganic or organic. We have firmly established the Law of Gravitation; but we know not what force it is that pushes or pulls mass towards mass. We speak of Cohesion, but we can only speculate on the power which compels molecule to cohere to molecule. We have supposed ourselves familiar with capillarity; but since M. E. Becquerel has shown us that the surface-attraction which compels the rise of fluids within a tube is sufficient to separate metals from their combinations with acids, and deposit them in films upon the attracting surface,* we discover that we have to study the indications of some occult power. The Osmose forces, again, have been so fully investigated by Professor Graham, that we begin to see that they involve all the phenomena of condensation which are exhibited by porous bodies, and that solution, diffusion, transpiration, and probably chemical attraction are but modified manifestations of some undeveloped force capable of producing new forms of energy.

Residing upon the surface of material atoms there is a power equal, if not superior, to the known physical forces, probably controlling, certainly modifying, their actual energies. This molecular power cannot be regarded as a mode of motion—it is a statical, rather than a dynamical force, yet it is the cause of actual energy.

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* As long since as the Meeting of the British Association at Southampton, Professor Oersted called attention to phenomena of this class.

The study of those powers which appear to act at insensible distances only, is gradually leading us to a knowledge of new conditions, which, probably, determine those dissimilar states under which we find matter of the same kind presenting itself, such as carbon and the diamond, oxygen and ozone, yellow and red phosphorus, and other elements. The relations existing between those molecular forces and the physical forces—Heat, Light, and Electricity—are at present too obscure to admit of the formation of any hypothesis. At the same time there are facts which inform us of some evident relations; and the careful study of these promises to place the inquirer upon new lands in the unexplored sea over which Newton looked from the shore on which he laboured, rich with the fruits of the trees of knowledge.

Everything, however, points to the establishment of the great fact that the sun is the reservoir of force; and it is constantly diffusing to all the worlds revolving around it, those energies which, at the beginning, converted a chaotic mass into a globe beautiful in its order, organization, and life. Matter changing its form in the sun develops an accurately-determined quantity of power, which, passing without loss through space, falls upon another mass of matter, and transmutes its atoms into a thousand forms, some brilliant as gems, others beautiful as flowers. The fine old fable of the Memnonian Statue, bursting into music at the first touch of the morning sunbeam, was but the outshadowing of a philosophic truth. Piercing through the darkness of night, the sunbeam touches the dormant earth, and establishes a series of undulations, which move onward in harmony and awaken the brute atoms into the divinest music. Touched by influences which can only be derived from the solar energies falling on the surface of the earth, the inorganic atoms, buried deep within the rocky crust, glide into geometric forms of beauty, and the crystal foretells the coming organization.

Such are the modern aspects of Physical Science; such are the wondrous truths which experimental inquiry is opening up to us. With so much to know, and with the deep consciousness of the little that we really do know, let us not indulge in the bewitching, but often bewildering labour of creating hypotheses; but, above all things, let us be careful to avoid advancing our hypothetical deductions from our inductive investigations into the importance of theories until they have been subjected to the severest tests.

When we have a theory which, like that of Gravitation, aids us in reaching far into space and feeling out a world which had never yet been detected by the eye of man, assisted even with his wonderful instrumental appliances—then may we accept it without a lingering doubt, and rely upon its power to advance us in the great task committed by his Creator to intellectual Man, of subduing the earth and holding dominion over it.

V. ON MUSICAL SCALES.

By Sir J. F. W. Herschel, Bart., F.R.S.

Having had my attention recently drawn to an ingenious attempt, by Mr. Jackson, to explain the relations between the Major and Minor scales in music, on the principle of the maximum of simplicity in the ratios of the vibrations of the several notes employed, I could not help being strongly impressed with the want of clearness introduced into the discussion of this subject by the employment of the fractions expressing the ratios of the vibrations, or of the lengths of the vibrating strings, and their multiplication or division one by another, to explain the relations of musical intervals. The elementary fractions concerned, $\frac{1}{2}$, $\frac{1}{3}$, and $\frac{1}{5}$, are, it is true, of the simplest kind; but their combinations, formed by multiplication and division, by whole numbers and by each other, present sufficient complexity to throw a kind of haziness over the perception of their magnitudes which distract attention. We have not quite so clear a perception of the magnitude of a fraction as of an integer number; and this indistinctness increases with the numerical increase of the numerator and denominator. Thus, to say which of two proposed fractions is the greater, if their numerators and denominators exceed a few units, often requires some consideration, and reduction to a common denominator; as for instance in the case of $\frac{7}{9}$ and $\frac{10}{13}$. The great majority too of those who study music do it as a subject *sui generis*, and not as a branch of mechanics. Their thoughts are directed to musical intervals and not to the vibrations which give rise to the sounds, or to the lengths of the strings which vibrate; and accordingly they find it far easier to conceive the interval (say) from C to E as the sum of the intervals from C to D and from D to E, than as a ratio compounded of two ratios expressive of these intervals severally. The use of logarithms, by the intervention of which musical intervals are treated as magnitudes susceptible of addition and substraction, and, like feet and inches, measurable on a scale (that scale being the finger-board of an imaginary pianoforte capable of yielding every gradation of audible tone from the lowest to the highest; the same interval corresponding to the same distance of the finger in every part of the scale and in every octave, higher or lower)—gets over this difficulty, and is accordingly often resorted to in treatises on music. In this, however, as in most other things, the proper choice of a unit is a matter of much importance. Every subject of mensuration has its natural unit: in angular measure, the circumference of the circle; in geodesy, the earth's polar axis; in time, the length of the day; and in music, the octave. The ordinary tabular logarithms, however, which give 0·30103, or (striking off the last two figures as unimportant, and multiplying by 1,000) 301 as the logarithm of 2, labour under two great disadvantages, *viz.* 1st, that of assuming an awkward incommensurable or prime number as the measure and representative of this natural unit; and 2ndly, that, in different octaves, the same note (by name) will come to be represented by a totally different and unrecognizable set of figures. Thus, for instance, taking the key-note *Do* as 0 and its octave *do* as 301, *Sol** will be expressed by 176; while *sol* (the same note in the next higher octave) will be expressed by 477 (176 + 301), in the next by 778 (176 + 602), and so on—figures which no way recall or suggest one another, and serve only uselessly to burden the memory. The same objection applies to the division of the octave into 1,200 equal parts, which, on the system of what is called "mean temperament," would assign 100 as the representative of a mean semitone; or into 600 (*temptingly near to* 2 × 301), which would give 100 for the expression of a mean tone.

Both these disadvantages are avoided by altering all the logarithms proportionally, so as to make 1,000 the logarithm of 2; or, speaking practically and without reference to any theory or to any mathematical phraseology, to regard the octave as divided into 1,000 equal intervals, each singly denoting a difference of tone so small as to be undistinguishable by the nicest ear, as the thousandth part of an inch would be to any ordinary eyesight. On this convention the numbers of such minute equal intervals, contained respectively in a Fifth (Vth), a Fourth (IVth), a Major Third (IIIrd), a Minor Third (3rd); a Major and a Minor tone, a Limma, and a Comma, are 585, 415, 322, 263, 170, 152, 93, and 18. The two first together make up an exact octave (585 + 415 = 1000), and are therefore complementary to each other, while the last is the difference between a Major and a Minor tone, the smallest interval recognized as such in musical language, and one which it requires a nice ear to discriminate. The way in which these numbers stand connected with each other is as follows:—the Octave being 1,000, the Fifth, $V. = 585$, and the Third,* $III. = 322$; then, denoting the Major tone by T, the Minor by t, the Limma by l, and the Comma by c, the IVth will be expressed by $1{,}000 - V.$, the Minor Third (263) by $V. - III.$; while T, t, l, and c will be respectively expressed by $T = 2V. - 1{,}000$, $t = 1{,}000 + III. - 2V.$, $l = 1{,}000 - V. - III.$, and $c = 4V. - III. - 2{,}000$; equations which, musically interpreted, express that the Minor Third is obtained from the fundamental or key note, by tuning upwards a Fifth, and thence, downwards, a Major Third; a Major tone, by tuning upwards two Fifths, and thence, downwards, an octave; and so of the rest.

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* I adhere throughout to the good old system of representing by *Do, Re, Mi, Fa*, &c., the scale of natural notes *in any key whatever*, taking *Do* for the key-note, whatever that may be, in opposition to the practice lately introduced (and soon, I hope, to be exploded) of taking *Do* to express one fixed tone C—the greatest retrograde step, in my opinion, ever taken in teaching music, or any other branch of knowledge.

As regards the numerical values of notes in higher or lower octaves, they are formed by adding in the former case, or subtracting in the latter, 1,000, 2,000, 3,000, &c., according to the number of octaves. Thus *Sol* being represented by 585, its representative numbers in the higher octaves will be 1,585, 2,585, &c., and in the lower by $585 - 1{,}000$, $585 - 2000$, &c., which, in order to preserve the same terminal figures 585, may be written (in analogy with what is usually done in ordinary logarithmic calculation) $\bar{1}{,}585$, $\bar{2}{,}585$, &c., the superscript negative sign applying only to the index figures 1, 2, &c., and the three terminal figures being regarded as always positive.

To those who study music simply *as* music, without troubling themselves with ratios, logarithms, or vibrations, it will save some trouble and bewilderment to accept these numbers as they stand, and to regard the interval called the Octave as made up of the seven successive intervals, T, t, l, T, t, T, l, constituting what is called the Diatonic Scale in its ordinary acceptation (though, as will be presently shown, the order T, t, of the two first intervals may be reversed, so as to give the scale t, T, l, T, t, T, l, without materially altering its character). It is thus that we accept the division of the year into twelve months of unequal lengths, and of these again into four weeks of seven days in each, with a greater or less number of supernumerary days. There is this difference, however, *viz.:* that the latter division is purely arbitrary, whereas the former is founded in the nature of harmony; and it will therefore not be amiss, before proceeding farther, to explain the *rationale* on which the scale is thus, as it were, built up, and how its elements come to succeed each other in this manner. It is recognized, then, as a matter of experience, that the intervals designated as an Octave, a Fifth, and a Major Third (1,000, 585, 322), and also the complement of the two latter to the Octave (1,000 − 585 = 415 and 1,000 − 322 = 678), and those formed by the addition to them of one or more octaves (as 1,000 + 585 = 1,585, and 2,000 + 322 = 2,322) are *perfectly* harmonious, and the only intervals in music which are so: for the Minor Third (263), though not unpleasing, or in any way *discordant*, leaves the ear in some degree unsatisfied, giving that melancholy expression to the Minor key which conveys the impression of something wanting to perfect happiness. Assigning, then, to each note in the scale *Do, Re, Mi, Fa, Sol, La, Si, do,* constituting the Octave, a numerical value expressing its interval or distance from the fundamental note *Do,* we have the two extremes *Do, do* designated respectively by 0 and 1,000, and three of the intermediate ones (*Mi* = 322; *Fa* = 415; and *Sol* = 585) will claim admission as perfect harmonics with the fundamental note or its octave. On the same ground also might 678 claim a place in the scale; but as it differs only by 93, or less than the tenth part of the octave from *Sol* already fixed, its admission would go to break up the octave into too small subdivisions; so that although an excellent candidate for admission into a chromatic scale of twelve semitones, as an intermediate between *Sol* and *La* it cannot be received into the scale of the *natural* notes. Regarding it, then, as an open question how to break the intervals between 0 and 322 on the one hand, and between 585 and 1,000 on the other, by introducing three more natural notes *Re, La,* and *Si;* it is evident that they ought to be determined (since they cannot harmonize with *Do* or *do*) by the condition of forming, each, if possible, perfectly harmonious combinations with one or more of the other three already fixed. This condition is satisfied by assigning to *Re* the number 170, which thus forms a IVth (585 − 170 = 415) with *Sol;* by 737 assigned to *La,* which thus affords a IVth (737 − 322 = 415) with *Mi,* and a IIIrd (737 − 415 = 322) with *Fa;* and by 907 assigned to *Si,* giving a Vth (907 − 322 = 585) with *Mi,* and a IIIrd (907 − 585 = 322) with *Sol.*

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* Whenever a "Third," without any adjunct, is spoken of, a *Major* Third is hereafter understood.

Thus, then, the natural scale is filled up. But here already occurs an alternative, and a choice of difficulties. As respects the positions of *La* and *Si* there can be no doubt. *La* besides standing in perfect harmony with *Mi* and *Fa* gives a minor Third (1,000 − 737 = 263) with the upper octave *Do,* an interval though somewhat less than harmonious (as already observed), yet indispensable in music, and without which a large region of human emotion would lack its musical expression; and *La* being thus fixed, *Si* can no otherwise be determined. As regards *Re,* however, it may equally well be determined by making it form a Vth with *La* (giving 737 − 585 = 152 for its value) as a IVth with *Sol,* which, as we have seen, gives 170. This latter, however, makes the interval between

Re and *La* $(737 - 170) = 567$, differing from a Vth by a comma, while the former, which makes this interval a good Vth, gives with *Sol* a IVth $(585 - 172 = 433)$ equally erroneous. Again, 170 assumed for *Re* gives a good Minor Third $(1{,}170 - 907 = 263)$ with *Si* below it, but a defective one $(415 - 170 = 245 = 263 - 18)$ with the *Fa* above it, while if 152 be used the result is simply reversed. Thus it appears that for *Re* two distinct values, 170 and 152, are equally eligible, thus originating two distinct diatonic scales. The former is that commonly received: the latter, by way of distinction, we shall speak of as the *Co-diatonic* Scale, as if complementary or correlative to the other.

If music were always played in one key, there would be no occasion for intermediate notes; but the change of key necessitates their introduction, and moreover introduces the further question of temperament, arising from the fact that no mere repetition, ascending or descending, of perfect Fifths or Thirds will lead to an exact Octave or Octaves of the note we set out from. The nearest approach in the case of Fifths is that of twelve Fifths $(12 \times 585 = 7{,}020 = 7{,}000 + 20)$, which exceed seven Octaves by 20, or rather more than a Comma.* The Thirds, whether major or minor, are still more rebellious, as appears from the equations $3 \times 322 = 966 = 1000 - 34$, and $4 \times 263 = 1052 = 1000 + 52$. By combining Fifths and Thirds, however, a much nearer approach may be made. Thus $2 \times 585 + 15 \times 322$ $(2\text{V} + 15\text{III}) = 6{,}000$, which shows that tuning upwards from *Re* (in the ordinary diatonic scale, where *Re* $= 170$), fifteen perfect Thirds will lead up precisely to the sixth Octave above *Do*. Again, we have $322 + 8 \times 585$ $(\text{III} + 8\text{V}) = 5{,}002 = 5{,}000 + 2$, which shows that tuning upwards from *Mi* eight perfect Fifths brings us within the ninth part of a Comma to an Octave of *Do*—a difference perfectly inappretiable. The former of these coincidences is of no value in musical theory; the latter, however, as will appear hereafter, affords the basis of a chromatic scale (*i.e.* a scale in which the Octave is divided into twelve intervals, designated, whether equal or unequal, as "semitones") so very slightly tempered that, practically speaking, it may be regarded as perfect in every key but one.

Dismissing, however, the subject of temperament, we shall now proceed to inquire (for the first time, I believe, on any distinct general principle) how the sharps and flats of the scale can be inserted on an instrument like the pianoforte admitting only of twelve keys on its finger-board within the compass of an Octave, so as to allow of transposition into *all* keys, both natural and sharp or flat, with the least possible deviation from a perfect scale in any one key, and with the greatest number of attainable perfect harmonics in the *ensemble* of all the twelve; bearing in mind, however, that the Fifth is a far more important harmonic than the Third.*

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* This interval is sometimes called a Pythagorean comma.

With this object, setting out, we will suppose, with the key of C on the pianoforte as our fundamental scale, let us denote by C, D, E, F, G, A, B, C′, the respective numbers above assigned as expressing the intervals from C of the natural notes so named, taking, in the first instance, 170 for the value of *Re;* or, let $C=0$; $D=170$; $E=322$; $F=415$; $G=585$; $A=737$; $B=907$; $C'=1000$: and let α, β, γ, δ, ϵ be taken to represent the numbers, at present unknown, to be assigned to the intermediate notes $C\sharp=D\flat$, $D\sharp=E\flat$, $F\sharp=G\flat$, $G\sharp=A\flat$, and $A\sharp=B\flat$; so that

$$C\,\alpha\,D\,\beta\,E\,F\,\gamma\,G\,\delta\,A\,\epsilon\,B\,C'$$

shall form the complete chromatic scale within the compass of an octave. Now, if we assume, for our fundamental or key note, each, in succession, of the twelve elements C, α, D, ... B, of the scale, the derivative scale will be formed by taking that note for our *Do*, the third from it in succession (counting the fundamental note as the first) for *Re*, the fifth in order for *Mi*, the sixth for *Fa*, the eighth for *Sol*, and so on: so that our aim must be to make as many of such derivative intervals (*Mi* – *Do*) as possible, perfect Thirds, as many from *Do* to *Fa* perfect Fourths, and from *Do* to *Sol* perfect Fifths as possible. These last conditions are identical; a Fourth ascending being equivalent to a Fifth descending. And it is evident that by proceeding thus through the whole scale, we shall get as many Thirds and Fifths as it is possible to make by combining its notes two and two. Our object then is, in effect, to assign such numerical values to our unknown symbols, α, β, γ, δ, ϵ, as shall satisfy as many as possible of the following equations.

(I.)

$E-C=322$, $F-\alpha=322$, $\gamma-D=322$, $G-\beta=322$, $\delta-E=322$, $A-F=322$, $\epsilon-\gamma=322$, $B-G=322$, $\delta-C\ (=1000-322)=678$, $A-\alpha=678$, $\epsilon-D=678$, $B-\beta=678$.

And (II.)

$F-C=415$, $\gamma-\alpha=415$, $G-D=415$, $\delta-\beta=415$, $A-E=415$, $\epsilon-F=415$, $B-\gamma=415$, $G-C\ (=1000-415)=585$, $\delta-\alpha=585$, $A-D=585$, $\epsilon-\beta=585$, $B-E=585$.

Of these 24 equations, eight, *viz.*: $E-C=322$, $A-F=322$, $B-G=322$, $F-C=415$, $G-D=415$, $A-E=415$, $G-C=585$, and $B-E=585$, are satisfied by the numerical values already assigned to these several letters; but the value of D so assigned (170) renders the equation $A-D=585$ self-contradictory, and this equation must be left unsatisfied, giving, as we have already observed, an imperfect Fifth.

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* I believe this is the general opinion among musicians; and it is justified by the important part it plays as the dominant of the scale, and as giving fullness and roundness to the harmony of the common chord.

The remaining 15 equations, when for C, D, E, &c., we substitute their assigned numerical values, divide themselves into two classes; those which give explicit values to the unknown quantities α, β, γ, &c., and those which give differential relations between them, thus:—

(III.)—EXPLICIT VALUES.

$$\alpha=59;\ \alpha=93;\ \beta=229;\ \beta=263;\ \gamma=492;\ \delta=644;\ \delta=678;\ \epsilon=848.$$

DIFFERENTIAL RELATIONS.

$$\epsilon-\gamma=322.$$

(IV.)—EXPLICIT VALUES.

$$\gamma=492;\qquad \epsilon=830.$$

DIFFERENTIAL RELATIONS.

$$\gamma-\alpha=415;\ \delta-\alpha=585;\ \delta-\beta=415;\ \epsilon-\beta=585;$$

of which the system (III.) contains those whose fulfilment secures perfect Thirds, and (IV.) those which secure perfect Fifths. And on them both we have to remark—1st. That not more than five distinct Thirds, in addition to the three which the natural notes afford, can be secured by *any* choice of α, β, γ, &c., by employing the equations (III.) 2ndly. That the same is true of Fifths *as secured by the equations* (IV.). And 3rdly. That these Thirds and Fifths are mutually exclusive, with the exception that the adoption of 492 as the value of γ, secures at once both a Fifth and a Third. To show this, it suffices to compare the values assigned by each set of equations separately, which are—

(V.), THOSE DEDUCED FROM (III.), *viz.:*—

$$\alpha=59 \text{ or } 93$$
$$\beta=229 \text{ or } 263$$
$$\delta=644 \text{ or } 678$$
$$\left\{\begin{matrix}\gamma=492\\ \text{and}\\ \epsilon=448\end{matrix}\right\} \text{ or } \left\{\begin{matrix}\gamma=492\\ \text{and}\\ \epsilon=814\end{matrix}\right\} \text{ or } \left\{\begin{matrix}\gamma=526\\ \text{and}\\ \epsilon=848\end{matrix}\right\}$$

AND (VI.), THOSE DERIVED FROM (IV.), BEING SIX DISTINCT SYSTEMS OF VALUES OBTAINED:

1st,	by excluding	$\gamma=492$;	*viz.*	$\alpha=75$,	$\beta=245$,	$\gamma=490$,	$\delta=660$,	$\epsilon=830$
2nd,	,,	$\epsilon=830$;	,,	$\alpha=77$,	$\beta=247$,	$\gamma=492$,	$\delta=662$,	$\epsilon=832$
3rd,	,,	$\gamma-\alpha=415$;	,,	$\alpha=75$,	$\beta=245$,	$\gamma=492$,	$\delta=660$,	$\epsilon=830$
4th,	,,	$\delta-\alpha=585$;	,,	$\alpha=77$,	$\beta=245$,	$\gamma=492$,	$\delta=660$,	$\epsilon=830$
5th,	,,	$\delta-\beta=415$;	,,	$\alpha=77$,	$\beta=245$,	$\gamma=492$,	$\delta=662$,	$\epsilon=830$
6th,	,,	$\epsilon-\beta=585$;	,,	$\alpha=77$,	$\beta=247$,	$\gamma=492$,	$\delta=662$,	$\epsilon=830$

These, however, are not the only Fifths obtainable; for among the value of α, β, γ, &c., given in (V.), there are six pairs which satisfy one or other of the differential relations in (IV.), *viz.* ($\alpha=59$, $\delta=644$), and ($\alpha=93$, $\delta=678$), either of which pairs satisfies $\delta-\alpha=585$. And again, ($\beta=229$, $\delta=644$), and ($\beta=263$,

$\delta=678$) which satisfy $\delta-\beta=415$. And lastly, ($\beta=229, \epsilon=814$) and ($\beta=263$, $\epsilon=848$): so that either of the two systems—

(VII.)

$$\alpha=59,\ \beta=229,\ \gamma=492,\ \delta=644,\ \epsilon=814$$
$$\alpha=93,\ \beta=263,\ \gamma=492,\ \delta=678,\ \epsilon=848$$

will satisfy the differential relations $\delta-\alpha=585$, $\delta-\beta=415$, and $\epsilon-\beta=585$, and will thus give us three more implied Fifths, without sacrificing either of the five Thirds which they imply, or the independent Fifth secured by taking $\gamma=492$.

On the other hand, any one of the systems of values in (VI.) will give us five Fifths, but their adoption necessarily sacrifices four out of the five Thirds given by (V.); that dependent on $\gamma=492$ being the only one retained. Here, however, our attention is naturally drawn to the singularly close coincidence of all the six values of α, β, γ, &c., in these systems (the direct consequence, be it observed, of that remarkable relation III. + 8 V. = 5000 + 2 we have already pointed out). And it will not fail to strike us that if we consent to overlook so very minute a deviation from absolute perfection in the value of ϵ as a single unit (a thousandth part of an octave, or 1-18th part of a comma, an interval no human ear is nice enough to distinguish), and adopt the series of values,

$$\alpha=77,\ \beta=247,\ \gamma=492,\ \delta=662,\ \epsilon=831,$$

we shall obtain *six* Fifths, four of which are perfect, and two defective only by the infinitesimal error above mentioned.

Thus, then, we have arrived at three scales, or chromatic subdivisions of the octave, which alone can be considered as having any distinct claim to preference among the innumerable systems which might be proposed, *viz.*:—

	Do		*Re*		*Mi*	*Fa*		*Sol*		*La*		*Si*	*do*
(A)	0,	93,	170,	263,	322,	415,	492,	585,	678,	737,	848,	907,	1000.
(B)	0,	59,	170,	229,	322,	415,	492,	585,	644,	737,	814,	907,	1000.
(C)	0,	77,	170,	247,	322,	415,	492,	585,	662,	737,	831,	907,	1000.

The first of these (A), when translated into the language of ratios and fractions, will be found to coincide with that given by Cavallo (Phil. Trans., vol. lxxviii., p. 239) as the then received harmonic subdivision of the octave into twelve intervals. The second (B) is one proposed by Euler;* while the third (C) coincides very nearly, so far as the accidental notes (the sharps or flats) are concerned, with either of the two *tempered* scales propounded by Dr.

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* I derive my knowledge of it from the Abbé Moigno's Journal, 'Annuaire du Cosmos,' 1859, part ii., p. 200. As there given, however, it is full of misprints. The fractions expressing the ratios of vibrations, evidently intended by Euler, are—

$$1,\ \tfrac{25}{24},\ \tfrac{9}{8},\ \tfrac{75}{64},\ \tfrac{5}{4},\ \tfrac{4}{3},\ \tfrac{45}{32},\ \tfrac{3}{2},\ \tfrac{25}{16},\ \tfrac{5}{3},\ \tfrac{225}{128},\ \tfrac{15}{8},\ 2.$$

Young in his 'Lectures on Natural Philosophy' (Lect. 33), which, translated into our language, are respectively—

Do *Re* *Mi* *Fa* *Sol* *La* *Si* *do*
0, 75, 163, 245, 327, 415, 490, 583, 660, 745, 830, 908, 1000;
And 0, 75, 164, 245, 322, 415, 490, 585, 660, 743, 830, 905, 1000;

in the latter of which it will be seen that with the exception of the single interval of 583 instead of 585, between *Mi* and *Si*, the semitones are all inserted by eight successive additions of 585 from *Mi* upwards: thus 323 + 583 = 905; 905 + 585 = 1,490; 1,490 + 585 = 2,075; 2,075 + 585 = 2,660; 2,660 + 585 = 3,245; 3,245 + 585 = 3,830; 3,830 + 585 = 4,415; 4,415 + 585 = 5,000: from which, rejecting the entire thousands so as to bring the notes all within the compass of one octave, we have a series of accidentals identical with the second of those set down in (VI.).

Let us now examine these three scales in succession, by forming out of them—1stly, all the Fifths; 2ndly, all the Major Thirds; and 3rdly, all the Minor Thirds which can be made among them, and we shall find as follows: *viz.* 1stly, for the scale (A)—

Vths—585, 585, 567, 585, 585, 585, 601, 585, 585, 585, 567, 585;
IIIrds—322, 322, 322, 322, 356, 322, 356, 322, 322, 356, 322, 356;
3rds—263, 229, 245, 229, 263, 263, 245, 263, 229, 263, 245, 263;

showing nine good Fifths, eight Major, and six Minor Thirds. The erroneous Fifths are, two of them, deficient by a Comma, and one in excess by nearly a Comma (16). The erroneous Major Thirds are all in excess by 34, or nearly two Commas; and the erroneous Minor Thirds all deficient, three by a Comma and three by 34.

The scale (B) similarly tried, gives—

Vths—585, 585, 567, 585, 585, 585, 567, 585, 585, 585, 601, 585;
IIIrds—322, 356, 322, 356, 322, 322, 322, 322, 356, 322, 356, 322;
3rds—229, 263, 245, 263, 263, 229, 245, 229, 263, 263, 245, 263;

which singularly enough (as it seems at first sight) exhibits the same number of each harmonic as (A), and the same amount of deviation, and in the same direction for each. These two scales then are precisely on a par, nor does there seem any reason for preferring one to the other. Both are rich in perfect Thirds both Major and Minor, which is a strong recommendation; but, owing to the bad Fifths which they involve, three out of the eleven keys into which the fundamental scale may be transposed are spoiled by false dominants, and three others blemished by false sub-dominants, while the more erroneous Thirds cannot but prove objectionable wherever they may occur.

Treating our scale (C) in the same manner, we get:—

Vths—585, 585, 567, 585, 585, 585, 585, 585, 585, 585, 584, 584;
IIIrds—322, 339, 321, 339, 339, 322, 340, 322, 339, 339, 339, 339;
3rds—246, 246, 245, 245, 263, 246, 246, 246, 246, 263, 245, 263;

Of the Fifths one only errs by a Comma, all the rest may be regarded as perfect, and the defective one (as we have seen) is inevitable if we insist on starting from an untempered scale. The chief blemish of this scale is the paucity of its perfect Thirds of both kinds, but on the other hand none of them err in excess or defect beyond a Comma.

The peculiarities of these several scales will, however, be placed in a clearer light by exhibiting the several scales of natural notes resulting from their transposition into all the keys. Taking then C for an original or fundamental key, the values of the natural notes in all the keys, starting from the scale (A), will stand thus:—

(A.)	C.	D♭.	D.	E♭.	E.	F.	G♭.	G.	A♭.	A.	B♭.	B.
Do ..	0	0	0	0	0	0	0	0	0	0	0	0
Re ..	170	170	152	152	170	170	186	152	170	170	152	186
Mi ..	322	322	322	322	356	322	356	322	322	356	322	356
Fa ..	415	399	415	415	415	433	415	415	415	433	415	415
Sol ..	585	585	567	585	585	585	601	585	585	585	567	585
La ..	737	755	737	737	771	755	771	737	737	755	737	771
Si ..	907	907	923	907	941	907	923	907	907	941	889	941
do ..	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

From which it appears that—1stly, the transposition into A♭ gives us back again the pure original scale of C unaltered; and, 2ndly, the transposition into either G or into E♭, gives again the diatonic scale, with the substitution of 152 instead of 170 for *Re*, constituting what we have above designated as the Co-diatonic scale.

Operating a similar series of transpositions with (B) as a fundamental scale, we find the following system—

(B.)	C.	D♭.	D.	E♭.	E.	F.	G♭.	G.	A♭.	A.	B♭.	B.
Do ..	0	0	0	0	0	0	0	0	0	0	0	0
Re ..	170	170	152	186	170	170	152	152	170	170	186	152
Mi ..	322	356	322	356	322	322	322	322	356	322	356	322
Fa ..	415	433	415	415	415	399	415	415	415	433	415	415
Sol ..	585	585	567	585	585	585	567	585	585	585	601	585
La ..	737	755	737	771	737	755	737	737	771	755	771	737
Si ..	907	941	889	941	907	907	923	907	941	907	923	907
do ..	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

Here we are again presented with a similar phænomenon. The exact original scale of C is reproduced in E♮, and the co-diatonic scale in the keys of G and B. Lastly, making the same series of transpositions in the case of our scale (C), we obtain—

(C.)	C.	D♭.	D.	E♭.	E.	F.	G♭.	G.	A♭.	A.	B♭.	B.
Do ..	0	0	0	0	0	0	0	0	0	0	0	0
Re ..	170	170	152	168	170	170	170	152	169	170	169	170
Mi ..	322	338	322	338	340	322	339	322	338	340	339	340
Fa ..	415	415	415	415	415	416	415	415	415	433	416	415
Sol ..	585	585	567	584	585	585	585	585	585	585	584	585
La ..	737	754	737	753	755	755	755	737	753	755	754	755
Si ..	907	923	907	923	925	907	923	907	923	925	906	924
do ..	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

where the co-diatonic scale appears in G, as in the case of (B). And it is sufficient to run the eye along the several horizontal lines of the table to perceive the much greater uniformity and regularity prevailing in this system than in the other two, between which it offers a sort of mean.

§ 2.

Let us now go through exactly the same set of operations, setting out from the co-diatonic scale in which $Re=152$; and instead of the system of values of α, β, &c. in (VII.), we shall find ourselves conducted to the following:—

(VIII.)

$$\alpha=59,\ \beta=229,\ \gamma=474,\ \delta=644,\ \epsilon=796;$$
$$\alpha=93,\ \beta=263,\ \gamma=508,\ \delta=678,\ \epsilon=830;$$

while the systems of values in (VI.) remain unaltered. Here, then, the link of connection between the two sets which give a Fifth in the one and a Third in the other, is $\epsilon=830$, instead of $\gamma=492$; and thus, proceeding as before, we are led to three scales, (a), (b), (c), each having its own especial claims to consideration.

Do *Re* *Mi* *Fa* *Sol* *La* *Si* *do*
(a) 0, 93, 152, 263, 322, 415, 508, 585, 678, 737, 830, 907, 1000.
(b) 0, 59, 152, 229, 322, 415, 474, 585, 644, 737, 796, 907, 1000.
(c) 0, 75, 152, 245, 322, 415, 491, 585, 660, 737, 830, 907, 1000.

Examining these by the criterion afforded by their Fifths and Major and Minor Thirds, as in the cases of the former scales, (A), (B), (C), we shall find that (a) affords, just as in the case of (A), nine perfect Fifths, and three excessive or defective by a Comma; eight perfect Major Thirds, and four excessive by 34; and six perfect Minor Thirds, three deficient by a Comma, and three by 34, or nearly two Commas.

The scale (b) similarly tried affords only eight perfect Fifths, three defective by a Comma, and one excessive by 34; eight perfect Major Thirds, the other four all excessive by 34; and seven perfect Minor Thirds, the others defective—two by 18, two by 34, and one by 52. This scale, then, is decidedly inferior, and may at once be rejected.

Lastly, (c) affords eleven Fifths (two defective by a single unit, and therefore to be received as perfect), and one defective by a Comma; the Major and Minor Thirds also as in the case of (C).

Rejecting, then, (b), the transpositions of (a) and (c) will give the following systems:—

(a.)	C.	D♭.	D.	E♭.	E.	F.	G♭.	G.	A♭.	A.	B♭.	B.
Do ..	0	0	0	0	0	0	0	0	0	0	0	0
Re ..	152	170	170	152	186	170	170	152	152	170	170	186
Mi ..	322	322	356	322	356	322	322	322	322	356	322	356
Fa ..	415	415	433	415	415	415	399	415	415	415	433	415
Sol ..	585	585	585	567	585	585	585	567	585	585	585	601
La ..	737	737	755	737	771	737	755	737	737	771	755	771
Si ..	907	907	941	889	941	907	907	923	907	941	907	923
do ..	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

And,

(c.)	C.	D♭.	D.	E♭.	E.	F.	G♭.	G.	A♭.	A.	B♭.	B.
Do ..	0	0	0	0	0	0	0	0	0	0	0	0
Re ..	152	170	170	170	169	170	169	152	170	170	170	168
Mi ..	322	340	339	340	338	322	339	322	340	338	322	338
Fa ..	415	416	433	415	415	415	416	415	415	415	415	415
Sol ..	585	585	585	585	585	585	584	567	585	585	585	584
La ..	737	755	755	755	753	737	754	737	755	754	755	753
Si ..	907	925	923	905	923	907	924	906	925	923	907	923
do ..	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

Here we see reproduced in the scale (a) the peculiarity already noticed in (A), *viz.* that it gives to A♭ the same identical scale with C and in D♭, (and with the exception of the single note *La*, also in B♮), the diatonic scale complementary to that we started from. Among the transpositions of (c), again, we find the key of F reproducing the complementary diatonic.

Except these five scales, it does not appear possible to construct any others having the smallest pretension to be received, consistently with the condition of starting from one or the other of the two *untempered* diatonics,* unless, perhaps, we regard as entitled to enter into this competition that bugbear to the musical mind, the scale which arises from tuning up directly from *Do* eleven consecutive perfect Fifths; the twelfth (which, with tempered Fifths, would lead to the seventh octave of the fundamental note), surpassing it by 20, or by what is called a "Pythagorean Comma," and so throwing "the wolf," as the phrase is, deliberately into one key, whose dominant, deficient by that amount, shall render it altogether unfit for use. To find the values of the notes in this scale, we have only to form the eleven first multiples of 585, reject the thousands, and arrange the results in order of magnitude, which gives the scale—

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* The minute temperament of a single unit in the two intermediate Fifths of the scales (C) and (c), it will be observed, does not affect any of the *Natural* notes of the fundamental scale. In those proposed by Dr. Young, on the other hand, the temperament is made to fall *entirely* on those notes, the accidentals being all free from it.

	Do		*Re*		*Mi*	*Fa*		*Sol*		*La*		*Si*	*do*
(*d*)	0,	95,	170,	265,	340,	435,	510,	585,	680,	755,	850,	925,	1000.

This scale, tried by the same test of Fifths and Major and Minor Thirds, gives us eleven perfect Fifths, and one deficient by 20; four Major Thirds deficient only by 2, and which therefore may be received as good, and all the other eight excessive by a Comma; and four Minor Thirds excessive by 2, and therefore to be received as good, all the rest being deficient by a Comma. This scale, then, so far from meriting the unreserved condemnation with which it has been received, stands in no *very* unfavourable comparison with (C) or (c) (though certainly inferior to both), in the original key, while in its transpositions (taking C as the original key) it exhibits some remarkable peculiarities which render it otherwise worthy of attention, as the following table will show:—

(d.)	C.	D♭.	D.	E♭.	E.	F.	G♭.	G.	A♭.	A.	B♭.	B.
Do ..	0	0	0	0	0	0	0	0	0	0	0	0
Re ..	170	170	170	170	170	150	170	170	170	170	150	170
Mi ..	340	340	340	320	340	320	340	340	320	340	320	340
Fa ..	435	415	415	415	415	415	415	415	415	415	415	415
Sol ..	585	585	585	585	585	565	585	585	585	585	585	585
La ..	755	755	755	735	755	735	755	755	755	755	735	755
Si ..	925	905	925	905	925	905	925	925	905	925	905	925
do ..	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
(e.)	A.	B♭.	B.	C.	D♭.	D.	E♭.	E.	F.	G♭.	G.	A♭.
(f.)	D.	E♭.	E.	F.	G♭.	G.	A♭.	A.	B♭.	B.	C.	D♭.

This table, as it stands, with the headings of the columns as on the upper horizontal line marked (d), exhibits the transpositions of the scale (d), starting with C as a fundamental note. It affords two very good scales, *viz.* a good, almost a perfect, diatonic scale in E♭, and an equally good co-diatonic in B♭; so that in those keys it will afford excellent harmony. What seems to condemn it is, that it throws "the wolf" into F, one of the most useful keys, and what may be called "the counter-wolf" (that which results from a faulty IVth—*for every faulty Fifth in one key necessitates an equally faulty Fourth in the key a fourth below it*) into the original key C itself. This unlucky defect, however, it is evident, will be evaded by starting, and beginning to tune our Fifths upwards, not from C but from E♭ or B♭, which will simply transfer the letters in the heading (d) into the order (e) in the upper of the two lines below the table in the former case, and into the order (f) in the latter case; and will give us for the values of the notes in the two scales as under—

	Do		*Re*		*Mi*	*Fa*		*Sol*		*La*		*Si*	*do*
(e)	0,	75,	170,	245,	320,	415,	490,	585,	660,	735,	830,	905,	1000;
(f)	0,	75,	150,	245,	320,	415,	490,	585,	660,	735,	830,	905,	1000;

whose approximation to our scales (C) and (c) is very close.

Exactly in the same manner, if we set out with either of the scales (A), (B), and, instead of commencing with C as a fundamental note, commence with A♭, as *Do*, and tune upwards thence by the successive intervals *of the other scale* in their order, from the beginning to the end of the octave. we shall complete the scale—thus, commencing with 678, which corresponds to A♭ in the scale (A), and adding to it in succession each of the numbers 59, 170, 229, 322, &c., belonging to the scale (B), we produce the numbers 737; 848; 907; 1,000; 1,093; 1,170, 1,263; 1,322; 1,415; 1,492; 1,585; 1,678; and *vice versâ*. This places in evidence the musical relation of those two scales, and shows that in fact each of them is only a transposition of the other.

The scale of equal temperament results from tuning upwards from *Do* twelve successive Fifths, each defective by $\frac{20}{12}$, or each = $583\frac{1}{3}$; or, which comes to the same, dividing the octave into equal intervals of $83\frac{1}{3}$ each, thus giving the scale (to the nearest unit in each note)—

	Do		*Re*		*Mi*	*Fa*		*Sol*		*La*		*Si*	*do*
(g)	0,	83,	167,	250,	333,	417,	500,	583,	667,	750,	833,	917,	1000.

This scale, of course, reproduces itself in all its transpositions, and is therefore exceedingly well adapted to the purposes of the mere Pianiste as affording him an unbounded range of modulation, and (by the free use of the equivocal chord, or diminished Seventh, and other similar artifices of modulation) allowing him, within the compass of the same piece of music, to pass into any, or if he please, all the keys, without fear of encountering "the wolf," or any other musical monster but those of his own making. Its chief defect is that it does not afford a single good Third, either Major or Minor; *all* the former being two-thirds of a Comma in excess, and *all* the latter as much in defect of their legitimate values. This is little felt in modern pianoforte music, in which brilliancy and rapidity of passages and startling turns of modulation, by the introduction of all sorts of extraneous notes into the discords, stand in the place of delicate and sustained harmony; to which, besides, the instrument itself is little adapted, owing to the rapid degradation in the intensity of sound in its notes when once struck. As an accompaniment, however, to instruments without a fixed scale, and more especially to vocal music in parts, where the performers, if they have any ear, will naturally endeavour to keep their Thirds perfect in those passages in which many of them follow in succession, on which so much of the beauty of vocal music depends, the advantage of a scale abounding in *perfect* Thirds is evident; especially if the composer, aware of the existence of faulty ones in the scale, should avoid their introduction, or avoid, at least, dwelling long on them.

To show the composition of the several numbers which occur in the foregoing scales, or what musical intervals they represent, we subjoin the following table, in which it is to be remembered that the entire thousands (expressive of octaves), whether + or −, are rejected; or in other terms, that − V (a Fifth tuned downwards) is to be considered as equivalent to + IV = 415, a Fourth tuned upwards; and − III., a descending Third, to = 678, its complement to the octave, ascending; and in which it must also be borne in mind that though these equations may be added to or substracted from one another or multiplied by any whole number, they must not be halved, quartered, or otherwise divided.

Table of Musical Equivalents in the foregoing pages, the Octave being 1000.

1 = − 2 III. + 37 V.	247 = + III. + 5 V.	644 = + 2 III.
2 = + III. + 8 V.	263 = − III. + V.	660 = − 4 V.
16 = − 2 III. − 4 V.	265 = + 9 V.	662 = + III. + 4 V.
18 = − III. + 4 V.	320 = − 8 V.	678 = − III.
20 = + 12 V.	322 = + III.	680 = + 8 V.
34 = − 3 III.	338 = − III. − 4 V.	735 = − 9 V.
36 = − 2 III. + 8 V.	340 = + 4 V.	737 = + III. − V.
52 = − 4 III. + 4 V.	415 = − V.	753 = − III. − 5 V.
59 = + 2 III. − V.	433 = − III. + 3 V.	755 = + 3 V.
75 = − 5 V.	435 = + 11 V.	771 = − 2 III. − V.
77 = + III. + 3 V.	474 = + 2 III. − 2 V.	796 = + 3 III. − 2 V.
93 = − III. − V.	490 = − 6 V.	814 = + 2 III. + 2 V.
95 = + 7 V.	492 = + III. + 2 V.	830 = − 2 V.
111 = − 2 III. + 3 V.	508 = − III. − 2 V.	832 = + III. + 6 V.
150 = − 10 V.	510 = − 6 V.	850 = + 10 V.
152 = + III. − 2 V.	526 = − 2 III. + 2 V.	889 = + 2 III. − 3 V.
168 = − III. − 6 V.	565 = − 11 V.	905 = − 7 V.
170 = + 2 V.	567 = + III. − 3 V.	907 = + III. + V.
186 = − 2 III. − 2 V.	583 = − III. − 7 V.	923 = − III. − 3 V.
229 = + 2 III. + V.	585 = + V.	925 = + 5 V.
245 = − 3 V.	601 = − 2 III. − 3 V.	941 = − 2 III. + V.

VI. ON THE MEASUREMENT OF THE LUMINOUS INTENSITY OF LIGHT.

By William Crookes, F.R.S., &c.

The measurement of the intensity of a ray of light is a problem the solution of which has been repeatedly attempted, but with less satisfactory results than the endeavours to measure the other radiant forces. The problem is susceptible of two divisions:—the absolute and the relative measurement of light.

I. Given a luminous beam, we may require to express its intensity by some absolute term having reference to a standard obtained at some previous time, and capable of being reproduced with accuracy at any time in any part of the globe. Possibly two such standards would be necessary, differing greatly in value, so that the space between them might be subdivided into a definite number of equal parts; or the same result might perhaps be obtained by the well-known device of varying the apparent intensity of the standard light by increasing and diminishing its distance from the instrument.

II. The standard of comparison, instead of being obtained once for all, like the zero and boiling-points of a thermometer, may be compared separately at each observation; and the problem then becomes somewhat simplified into the determination of the relative intensities of two sources of light.

The *absolute* method is of course the most desirable; but as the preliminary researches and discoveries are yet to be made before a photometer, analogous to a thermometer in fixity of standard and facility of observation, could be devised, the realization of an absolute light-measuring method appears somewhat distant. The path to be pursued towards the attainment of this desirable object appears to be indicated in the observations which from time to time have been made by Becquerel, Herschel, Hunt, and others on the chemical action of the solar rays, and the production thereby of a galvanic current, capable of measurement on a delicate galvanometer, by appropriate arrangements of metallic plates and chemical baths connected with the ends of the galvanometer wires.

Many so-called photometers have been devised, by which the chemical action of the rays at the most refrangible end of the spectrum have been measured, and the chemical intensity of light tabulated by appropriate methods; and within the last few years Professors Bunsen and Roscoe have contrived a perfect chemical photometer, based upon the action of the chemical rays of light on a gaseous mixture of chlorine and hydrogen, causing them to combine with formation of hydrochloric acid.

But the measurement of the chemical action of a beam of light, is as distinct from photometry proper as is the thermometric registration of the heat rays constituting the other end of the spectrum. What we want is a method of measuring the intensity of those rays which are situated at the intermediate parts of the spectrum, and produce in the eye the sensation of light and colour; and, as previously suggested, there is a reasonable presumption that further researches may place us in possession of a photometric method based upon the chemical action of the *luminous* rays of light.

The rays which affect an ordinary photographic sensitive surface, are so constantly spoken of and thought about as the ultra-violet invisible rays, that it is apt to be forgotten that some of the highly luminous rays of light are capable of exerting chemical action. Fifteen years ago the writer was engaged in some investigations on the chemical action of light, and he succeeded in producing all the ordinary phenomena of photography, even to the production of good photographs in the camera, by purely luminous rays of light free from any admixture with the violet and invisible rays. When the solar spectrum, of sufficient purity to show the principal fixed lines, is projected for a few seconds on to a sensitive film of iodide of silver, and the latent image then developed, the action is seen to extend from about the fixed line G to a considerable distance into the ultra-violet invisible rays. When the same experiment was repeated with a sensitive surface of bromide of silver instead of iodide of silver, the result of the development of the latent image showed that in this case the action commenced at about the fixed line *b*, and extended, as in the case of the iodide of silver, far beyond the violet. A transparent cell, with parallel glass sides one inch across, was filled with a solution of twenty-five parts of sulphate of quinine to one hundred parts of dilute sulphuric acid; this was placed across the path of the rays of light, and photographs of the spectrum were again taken on iodide of silver and on bromide of silver, the arrangements in all cases being identical with those in the first cited experiments, with the exception of the interposition of the quinine screen. The action of the sulphate of quinine upon a ray of light is peculiar; to the eye it scarcely appears to have any action at all, but it is absolutely opaque to the ultra-violet, so called chemical, rays, and thus limits the photographic action on the bromide and iodide of silver to the purely luminous rays. On developing the latent images, it was now found that the action on iodide of silver was confined to a very narrow line of rays, close to the fixed line G, and in the case of bromide of silver to the space between *b* and G. Designating the spaces of action by colours instead of fixed lines, it was thus proved that, behind a screen of sulphate of quinine, iodide of silver was affected only by the luminous rays about the centre of the indigo portion of the spectrum, whilst bromide of silver was affected by the green, blue, and some of the indigo rays.

It is very likely that a continuance of these experiments would lead to the construction of a photometer capable of measuring the luminous rays; for although bromide of silver behind quinine is not affected by the red or yellow rays, still it is by the green and blue; and as the proportion of red, yellow, green, and blue rays is always invariable in white light (or the light would not be white but coloured), a method of measuring the intensity of one set of the components of white light would give all the information we want; just as, in an analysis of a definite chemical compound, the chemist is satisfied with an estimation of one or two constituents only, and calculates the others.

Method based upon the foregoing considerations would supply us with what may be termed an *absolute* photometer, the indication of which would be always the same for the same amount of illumination, requiring no standard light for comparison; and pending the development of experiments which the writer is prosecuting in this direction, he has been led to devise a new and, as he believes, a valuable form of *relative* photometer.

A relative photometer is one in which the observer has only to determine the relative illuminating powers of two sources of light, one of which is kept as uniform as possible, the other being the light whose intensity is to be determined. It is therefore evident that the great thing to be aimed at is an absolutely uniform source of light. In the ordinary process of photometry the standard used is a candle, defined by Act of Parliament as a "sperm candle of six to the pound, burning at the rate of 120 grains per hour." This is the standard from which estimates of the value of illuminating gas are deduced, hence the terms "12-candle gas," "14-candle gas," &c. In his work on *Gas Manipulation*, Mr. Sugg gives a very good account of the difficulties which stand in the way of obtaining uniform results with the Act of Parliament candle. A true sperm candle is made from a mixture of refined sperm with a small proportion of wax, to give it a certain toughness, the pure sperm itself being extremely brittle. The wick is of the best cotton, made up into three cords and plaited. The number of strands in each of the three cords composing the wick of a six-to-the-pound candle is seventeen, although Mr. Sugg says there does not appear to be any fixed rule, some candles having more and others less, according to the quality of the sperm. Sperm candles are made to burn at the rate of one inch per hour, and the cup should be clean, smooth, and dry. The wick should be curved slightly at the top, the red tip just showing through the flame, and consuming away without requiring snuffing. To obtain these results, the tightness of the plaiting and size of the wick require careful attention; and as the quality of the sperm differs in richness or hardness, so must the plaiting and number of strands. A variety of modifying circumstances thus tend to affect the illuminating power of a standard sperm candle. These difficulties, however, are small, compared with those which have resulted from the substitution of paraffin, &c., for part of the sperm; and Mr. Sugg points out that candles can be made with such combinations of stearin, wax, or sperm, and paraffin, as to possess all the characteristics of sperm candles, and yet be superior to them in illuminating power; while, on the other hand, candles made from the same materials otherwise combined are inferior. When, in addition to this, it is found that candles containing paraffin require wicks more tightly plaited and with fewer strands than those suitable for the true sperm candle, our readers will be enabled to judge of the almost unsurmountable difficulties which beset the present system of photometry.

But assuming that the true parliamentary sperm candle is obtained, made from the proper materials and burning at the specified rate, its illuminating power will be found to vary with the temperature of the place where it has been kept, the time which has elapsed since it was made, and the temperature of the room wherein the experiment is tried.

The Rev. W. R. Bowditch, in his work on *The Analysis, Purification, &c., of Coal-gas*, enters at some length into the question of test-candles, and emphatically condemns them as light-measurers; one experiment quoted by this author showed that the same gas was reported to be 14·63 or 17·36 candle gas, according to the way the experiment was conducted.

The present writer has taken some pains to devise a source of light which should be at the same time fairly uniform in its results, would not vary by keeping, and would be capable of accurate imitation at any time and in any part of the world by mere description. The absence of these conditions seems to be one of the greatest objections to the sperm candle. It would be impossible for an observer on the continent, ten or twenty years hence, from a written description of the sperm candle now employed, to make a standard which would bring his photometric results into relation with those obtained here. Without presuming to say positively that he has satisfactorily solved all difficulties, the writer believes that he has advanced some distance in the right direction, and pointed out the road for further improvement.

Before deciding upon a standard light, experiments were made to ascertain whether the electric current could be made available. Through a coil of platinum wire, so as to render it brightly incandescent, a powerful galvanic current was passed; and its strength was kept as constant as possible by a thick wire galvanometer and rheostat. To prevent the cooling action of air-currents, the incandescent coil was surrounded with glass; and it was hoped that by employing the same kind of battery and by varying the resistance so as to keep the galvanometer needle at the same deflection, uniform results could be obtained. In practice, however, it was found that many things interfered with the uniformity of the results, and the light being much feebler than it was advisable to work with, this plan was deemed not sufficiently promising, and it was abandoned. The method ultimately decided upon is the following:—Alcohol of sp. gr. 0·805, and pure benzol boiling at 81 C., are mixed together in the proportion of 5 volumes of the former and 1 of the latter. This burning fluid can be accurately imitated from description at any future time and in any country, and if a lamp could be devised equally simple and invariable, the light which it would yield would, it is presumed, be invariable. This difficulty the writer has attempted to overcome in the following manner.

A glass lamp is taken of about two ounces capacity, the aperture in the neck being 0·25 inch diameter; another aperture at the side allows the liquid fuel to be introduced; and by a well-known laboratory device, the level of the fluid in the lamp can be kept uniform. The wick-holder consists of a platinum tube 1·81 inches long and 0·125 inch internal diameter. The bottom of this is closed with a flat plug of platinum, apertures being left in the sides to allow free access of spirit. A small platinum cup 5 inches diameter and 1 inch deep is soldered round the outside of the tube 0·5 inch from the top, answering the threefold purpose of keeping the wick-holder at a proper height in the lamp, preventing evaporation of the liquid, and keeping out dust. The wick consists of 52 pieces of hard-drawn platinum wire, each 0·01 inch in diameter and 2 inches long, perfectly straight and tightly pushed down into the platinum holder until only 0·1 inch projects above the tube. The height of the burning fluid in the lamp must be sufficient to cover the bottom of the wick-holder: it answers best to keep it always at the uniform distance of 1·75 inches from the top of the platinum wick; a slight variation of level, however, has not been found to influence the light to an extent appreciable by our present means of photometry. The lamp with reservoir of spirit thus arranged, with the platinum wires parallel and their projecting ends level, a light is applied, and the flame instantly appears, forming a perfectly-shaped cone 1·25 inches in height, the point of maximum brilliancy being 0·56 inch from the top of the wick. The extremity of the flame is perfectly sharp, without any tendency to smoke; without flicker or movement of any kind, it burns when protected from currents of air at a uniform rate of 136 grains of liquid per hour. The temperature should be about 60° F., although moderate variations on either side exert no perceptible influence.

There is no doubt that this flame is very much more uniform than that of the sperm candle sold for photometric purposes. Tested against a candle, considerable variations in relative illuminating power have been observed; but on placing two of these lamps in opposition, no such variations have been detected. The same candle has been used, and the experiments have been repeated at wide intervals, using all usual precautions to ensure uniformity. The results are thus shown to be due to variations in the candle and not in the lamp.

It is expected that whoever may be inclined to adopt the kind of lamp here suggested will find not only that its uniformity may be relied upon, but that, by following accurately the description and dimensions here laid down, each observer will possess a lamp of equivalent and convertible photometric value; so that results may not only be strictly comparable between themselves, but, within slight limits of accuracy, comparable with those obtained by other experimentalists. The dimensions of wick, &c., here laid down are not intended to fix the standard. Persons engaged in photometry as an important branch of their regular occupation will be better able to fix these data than the writer, by whom photometry is only occasionally pursued as a means of scientific research. Already many improvements suggest themselves, and several causes of variation in the light have been noticed. Future experiments may point out how these sources of error are to be overcome; but at present there is no necessity to refine our source of standard light to a greater degree of accuracy than the photometric instrument admits of.

The instrument for measuring the relative intensities of the standard and other lights, next demands attention. The contrivances in ordinary use are so well known that a short sketch of the principles on which they are based need only be given. Most of them depend on a well-known law in optics, namely, that the amount of light which falls upon a given surface varies inversely as the square of the distance between the source of light and the object illuminated. The simplest observation which can be taken is made by placing two sources of light (say a candle and gas-lamp) opposite a white screen a few feet off, and placing a stick in front of them, so that two shadows of the stick may fall on the screen. The strongest light will cast the strongest shadow; and by moving this light away from the stick, keeping the shadows side by side, a position will at last be found at which the two shadows appear of equal strength. By measuring the distance of each light from the screen, and squaring it, the product will give the relative intensities of the two sources of light.

In practice, this plan is not sufficiently accurate to be used except for the roughest approximations; and from time to time several ingenious contrivances, all founded upon the same law, have been introduced by scientific men, by which a much greater accuracy is obtained; thus, in Ritchie's photometer the lights are reflected on to a piece of oiled paper in a box, and their distances are varied until the two halves of the paper are equally illuminated. In Bunsen's photometer, which is the one now generally used, the lights shine on opposite sides of a disc of white paper, part of which has been smeared with melted spermaceti to make it more transparent. When illuminated by a front light the greased portion of the paper will look dark; but if the observer goes to the other side of the paper, the greased part looks the lighter. If therefore lights of unequal intensity are placed on opposite sides of a piece of paper so prepared, a difference will be observed; but by moving one backwards or forwards, so as to equalize the intensity, the whole surface of the paper will appear uniformly illuminated on both sides. This photometer has been modified by many observers. By some the disc of paper is moved, the lights remaining stationary; by others the whole is enclosed in a box, and various contrivances are adopted to increase the sensitiveness of the eye and to facilitate calculation: but in all these the sensitiveness is not materially augmented, as the eye cannot judge of very minute differences of illumination approximating to equality.

In 1833 Arago described a photometer in which the phenomena of polarized light were employed. This instrument is fully described, with drawings, in the tenth volume of the *Œuvres Complètes de François Arago;* but the description, although voluminous, is far from clear. The principle of its construction is founded on "the law of the square of the cosines," according to which polarized rays pass from the ordinary to the extraordinary image. The knowledge of this law, he says, will not only prove theoretically important, but will further lead to the solution of a great number of very important astronomical questions. Suppose, for example, that it is wished to compare the luminous intensity of that portion of the moon directly illuminated by the solar rays with that of the part which receives only light reflected from the earth, called the *partie cendrée.* Were the law in question known, the way to proceed would be as follows:—after having polarized the moon's light, pass it through a doubly refracting crystal, so disposed that the rays, not being able to bifurcate, may entirely undergo ordinary refraction. A lens placed behind this crystal will therefore show but one image of our satellite; but as the crystal in rotating on its axis passes from its original position, the second image will appear, and its intensity will go on augmenting. The movement of the crystal must be arrested at the moment when, in this growing extraordinary image, the segment corresponding to the part of the moon illuminated by the sun, exhibits the intensity of the ashy part shown by the ordinary image. From these data it is easy to perceive, he says, that the problem is capable of solution.

In another part of the same volume, after speaking of the polariscope which goes by his name, Arago writes:—"I have now arrived at the general principle upon which my photometric method is entirely founded. The quantity (I do not say the proportion)—the quantity of completely polarized light, which forms part of a beam partially polarized by reflection, and the quantity of light polarized rectangularly which is contained in the beam transmitted under the same angle, are exactly equal to each other. The reflected beam and the beam transmitted under the same angle by a sheet of parallel glass, have in general very dissimilar intensities; if however we examine with a doubly refracting crystal, first the reflected and then the transmitted beam, the greatest difference of intensity between the ordinary and the extraordinary images will be the same in the two cases, because this difference is precisely equal to the quantity of polarized light which is mixed with the common light."

In Arago's astronomy, the author again describes his photometer in the following words: "I have constructed an apparatus by means of which, upon operating with the polarized image of a star, we can succeed in attenuating its intensity by degrees exactly calculable after a law which I have demonstrated." It is difficult to obtain an exact idea of this instrument from the description given; but from the drawings it would appear to be exceedingly complicated, and to be different in principle and construction from the one now about to be described. The present photometer has this in common with that of Arago as well as with those described in 1853 by Bernard,* and in 1854 by Babinet,† that the phenomena of polarized light are used for effecting the desired end. But it is believed that the present arrangement is quite new, and it certainly appears to answer the purpose in a way which leaves little to be desired. The instrument will be better understood if the principles on which it is based are first described.

FIG. 1.

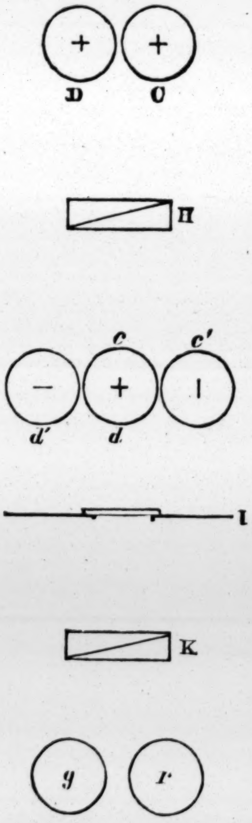

Fig. 1 shows a plan of the arrangement of parts, not drawn to scale, and only to be regarded as an outline sketch to assist in the comprehension of general principles. Let D represent a source of light. This may be a white disc of porcelain or paper illuminated by any artificial or natural light. C represents a similar white disc likewise illuminated. It is required to compare the photometric intensities of D and C. (It is necessary that neither D nor C should contain any polarized light, but that the light coming from them, represented on each disc by the two lines at right angles to each other, forming a cross, should be entirely unpolarized.) Let H represent a double refracting achromatic prism of Iceland spar; this will resolve the disc D into two discs d and d', polarized in opposite directions; the plane of d being, we will assume, vertical, and that of d' horizontal. The prism H will likewise give two images of the disc C; the image c being polarized horizontally, and c' vertically. The size of the discs D, C, and the separating power of the prism H are to be so arranged that the vertically polarized image d, and the horizontally polarized image c, exactly overlap each other, forming, as shown in the figure, one compound disc $c\ d$, built up of half the light from D and half that from C.

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* 'Comptes Rendus.' April 25, 1853.

† 'Proceedings of the British Association,' Liverpool Meeting, 1854.

The measure of the amount of free polarization present in the disc $c\ d$, will give the relative photometric intensities of D and C.

The letter I represents a diaphragm with a circular hole in the centre, just large enough to allow the compound disc $c\ d$ to be seen, but cutting off from view the side discs c', d'. In front of the aperture in I is placed a piece of selenite of appropriate thickness for it to give a strongly-contrasting red and green image under the influence of polarized light. K is a doubly refracting prism, similar in all respects to H, placed at such a distance from the aperture in I that the two discs into which I appears to be split up are separated from each other, as at g, r. If the disc $c\ d$ contains no polarized light, the images $g\ r$ will be white, consisting of oppositely polarized rays of white light; but if there is a trace of polarized light in $c\ d$, the two discs $g\ r$ will be coloured complimentarily; the contrast between the green and red being stronger in proportion to the quantity of polarized light in $c\ d$.

The action of this arrangement will be readily evident. Let it be supposed in the first place that the two sources of light, D and C, are exactly equal. They will each be divided by H into two discs, $d'\ d$ and $c\ c'$, and the two polarized rays of which $c\ d$ is compounded will also be absolutely equal in intensity, and will neutralize each other and form common light, no trace of free polarization being present. In this case the two discs of light $g\ r$ will be colourless. Let it now be supposed that one source of light (D for instance) is stronger than the other (C). It follows that the two images $d'\ d$ will be more luminous than the two images $c\ c'$, and that the vertically polarized ray d will be stronger than the horizontally polarized ray c. The compound disc $c\ d$ will therefore shine with partially polarized light, the amount of polarization being in exact ratio with the photometric intensity of D over C. In this case the image of the selenite plate in front of the aperture I will be divided by K into a red and a green disc.

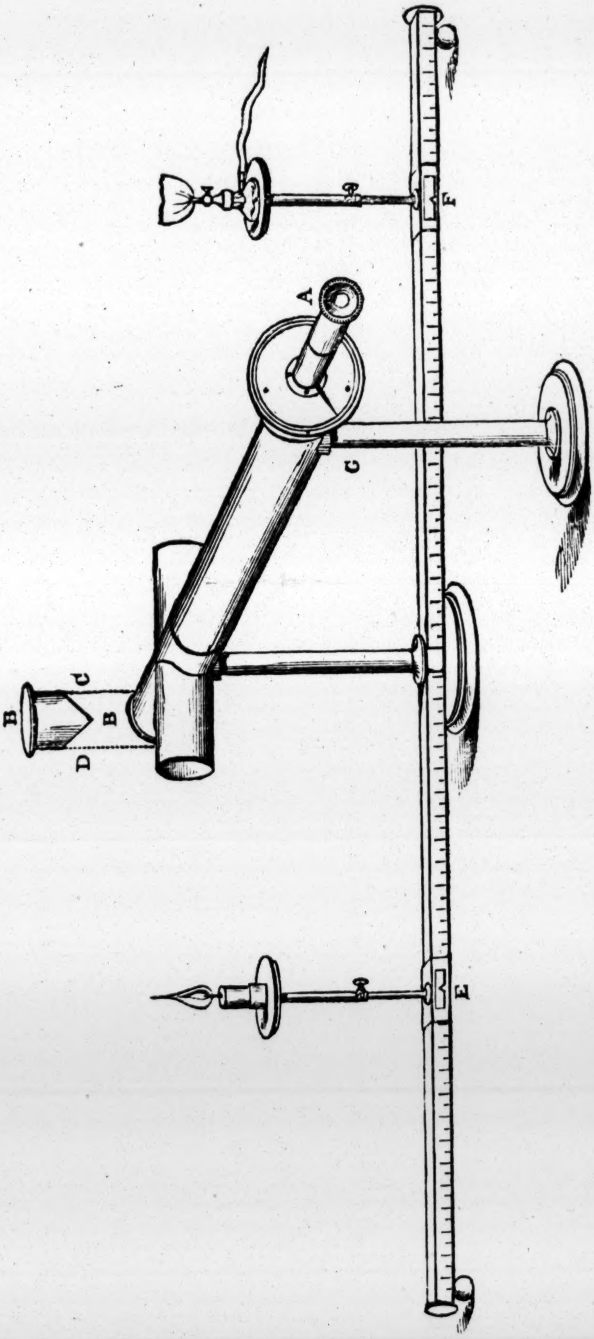
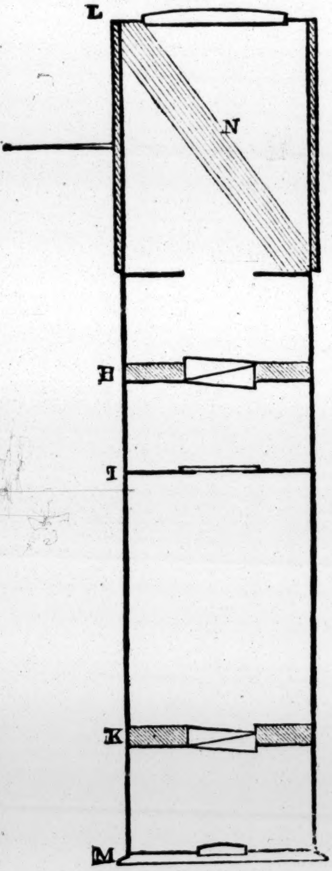


FIG. 2.

Fig. 2. shows the instrument fitted up. A is the eye-piece shown in enlarged section at Fig. 3. G B is a brass tube, blacked inside, having a piece, shown separate at D C, slipping into the end B. The sloping sides, D B, B C, are covered with a white reflecting surface (white paper or finely-ground porcelain), so that when D C is pushed into the end B, one white surface D B may be illuminated (as in Fig. 2) by the candle, and the other surface B C by the lamp. If the eye-piece A is removed, the observer, looking down the tube G B, will see at the end a luminous white disc divided into two parts, one half being illuminated by the candle E, and the other half by the lamp F. By moving the candle E, for instance, along the scale, the illumination of the half D B can be varied at will, the illumination of the other half remaining stationary.

The eye-piece A (shown enlarged at Fig. 3) will be understood by reference to Fig. 1, the same letters representing similar parts. At L is a lens to collect the rays from D B C (Fig. 2), and throw the image into the proper part of the tube. At M is another lens, so adjusted as to give a sharp image of the two discs into which I is divided by the prism K. The part N is an adaptation of Arago's polarimeter, which consists of a series of thin plates of glass capable of moving round the axis of the tube, and furnished with a pointer and graduated arc (shown at A, G, Fig. 2). By means of this pile it is possible to partially polarize the rays coming from the illuminated discs in one or the other direction, and thus bring to the neutral state the partially polarized beam *c d*, (Fig. 1,) so as to get the images *g r* free from colour. It is so placed that when at the zero point it produces an equal effect on both discs.

FIG. 3.



The action of the instrument is as follows. The standard lamp being placed on one of the supporting pillars which slide along the graduated stem (Fig. 2), it is adjusted to the proper height, and moved along the bar to a convenient distance, depending on the intensity of the light to be measured: the whole length being a little over four feet, each light can be placed at a distance of twenty-four inches from the disc. The flame is then sheltered from currents of air by black screens placed round, and the light to be compared is fixed in a similar way on the other side of the instrument. The whole should be placed in a dark room, or surrounded with non-reflecting screens; and the eye must also be protected from direct rays from the two lights. On looking through the eye-piece two bright discs will be seen, probably of different colours. Supposing E represents the standard flame and F the light to be compared with it, the latter must now be slid along the scale until the two discs of light, seen through the eye-piece, are about equal in tint. It has been found most convenient not to attempt to get absolute equality in this manner, but to move the flame to the nearest inch on one side or the other of equality. The final adjustment is now effected at the eye-end, by turning the polarimeter one way or the other up to 45° until the images are seen without any trace of colour. This will be found more accurate than the plan of relying entirely on the alteration of the distance of the flame along the scale; and by a series of experimental adjustments, the value of every angle through which the bundle of plates is rotated can be ascertained once for all, when the future calculations will present no difficulty. Squaring the number of inches between the flames and the centre will give their approximate ratios; and the number of degrees the eye-piece rotates will give the number to be added or subtracted in order to obtain the necessary accuracy.

The delicacy of the instrument is very great. With two lamps, each about twenty-four inches from the centre, it is easy to distinguish a movement of one of them to the extent of $\frac{1}{10}$th of an inch to or fro; and by using the polarimeter an accuracy considerably exceeding that can be attained.

The employment of a photometer of this kind enables us to compare lights of different colours with one another, and leads to the solution of a problem which, from the nature of their construction, would be beyond the powers of the instruments in general use. So long as the observer, by the eye alone, has to compare the relative intensities of two surfaces respectively illuminated by the lights under trial, it is evident that unless they are of the same tint it is impossible to obtain that absolute equality of illumination in the instrument which is requisite for a comparison. By the unaided eye one cannot tell which is the brighter half of a paper disc illuminated on one side with a reddish and on the other with a yellowish light; but by using the above-described photometer the problem becomes practicable. For instance, on reference to Fig. 1, suppose the disc D were illuminated with light of a reddish colour and the disc C with greenish light, the polarized discs *d′ d* would be reddish and the discs *c c′* greenish, the central disc *c d* being of the tint formed by the union of the two shades. The analyzing prism K and the selenite disc T will detect free polarization in the disc *c d* if it be coloured as readily as if it were white; the only difference being that the two discs of light *g r* cannot be brought to a uniform *white* colour when the lights from D and C are equal in intensity, but will assume a tint similar to that of *c d*. When the contrasts of colour between D and C are very strong—when, for instance, one is bright green and the other scarlet—there is some difficulty in estimating the exact point of neutrality; but this only diminishes the accuracy of the comparison, and does not render it impossible, as it would be according to other systems.

No attempt has been made in these experiments to ascertain the exact value of the standard spirit-flame in terms of the parliamentary sperm candle. Difficulty was experienced in getting two lots of candles yielding light of equal intensities, and when their flames were compared between themselves and with the spirit-flame, variations of as much as 10 per cent. were sometimes observed in the light they gave. Two standard spirit-flames, on the other hand, seldom showed a variation of 1 per cent., and had they been more carefully made they would not have varied 0·1 per cent.

This plan of photometry is capable of far more accuracy than the present instrument will give. It can scarcely be expected that the first instrument of the kind, roughly made by an amateur workman, should possess equal sensitiveness with one in which all the parts have been skilfully made with special adaptation to the end in view.

CHRONICLES OF SCIENCE.

1. AGRICULTURE.

Beyond the ordinary labours of the field preceding and succeeding seed time, which have this year been carried on under favourable circumstances, the subjects principally occupying agricultural attention during the past quarter have been rather of a social, or even political, than of a practical and scientific nature; and they are the less proper for discussion, or even enumeration here. We may, however, refer to the condition of the agricultural labourer as one of them. It has been properly enough characterized as extremely unsatisfactory in many parts of the country, where the ignorance of the class is very great and their wages very low. Schools are, however, bearing fruit everywhere, and the proportion of country workmen who can read and write a letter, is every year increasing; and the wages received by them, though still various in different districts (indicating the strength of tie which still holds the labouring population to their parish), is less various than the mere money paid to them would lead one to suppose. There are many districts where the money wages are declared to be only 9*s*. or 10*s*., or even less, a week, in which a man is better off than he would be in a town with 20*s*. to 25*s*. weekly. The real payment for services includes in the former case, cottage and garden, 5*l*. or 6*l*. for the harvest month, constant payment all the year, and the opportunity both of earning triple wages at occasional piecework and of buying cheap flour and fuel. In an instance known to us near Rochford, Essex, where the offer of a 5*l*. prize at length brought forth a properly vouched year's cash-account of the income and expenditure of an agricultural labourer who was receiving nominally 11*s*. a week, the actual receipts for the year exceeded 50*l*. Those who compare the nominal wages of the labourer in town and country, are thus contrasting things of entirely different character, and are in danger of misleading themselves and others. Good service will, nevertheless, we readily admit, be done by any one who shall set himself to help good working-men to improve their circumstances, by sending them from over-populated districts to places where labourers are more wanted, and wages accordingly are higher; and this has been done of late by the Rev. Canon Girdlestone, at Halberton, in Devonshire, to an extent which has at length excited public attention.

Returning now to our task as mere chroniclers of agricultural events, we have to mention Mr. Gülich's mode of potato growing, reported from Holstein, which has been designed with a view to escape the so-called potato disease. He grows his potato plants in hillocks, a yard apart every way, planting the tubers individually on earth over a spadeful of compost or manure in each spot, and taking care that each tuber is planted with the eye downwards. The shoots rise in a circle round the tuber, and in the course of their growth they are separated wider by additions of earth in the middle of this circle, and fall down into the intervening spaces whence the earth has been removed for this purpose. There is thus ultimately a set of hillocks of which the tops are bare and the base surrounded with foliage; and the idea is that the alleged freedom from disease which ensues must be owing to the blight fungus being washed downwards into the intervals between the plants, and away from the crop of young tubers which remain under the central hillock of bare earth.

The spring time of the year always brings round discussions of the injury done to farmers by fraud in the seed and the manure trades. It is alleged that the phrase "nett seed" is a common one among wholesale seedsmen, indicating that seed which is not "nett," and which therefore must be fraudulently mixed with dead and worthless additions, is also commonly delivered. There can be no doubt that the immense quantities of seed used in order to obtain an agricultural crop—often ten and twenty-fold the quantity which would, if all would grow, supply more than plants enough—can be explained only on the theory that a very large quantity of seed does not grow at all. Manures, in like manner, are the subject of fraudulent admixture; and sales by auction, professedly of damaged cargoes, often take-in the unwary who think to catch a bargain by cheap purchases of worthless stuff that is really dear at any price. Some service is done by repeatedly calling attention to the risks of this kind which the farmer runs; and we therefore mention the subject here.

The theory of the under-drainage of land has recently received some discussion in the agricultural journals. The policy of leaving the upper ends of pipe-drains open to the air has been defended on the ground that it facilitates the passage of water through the pipe. The idea seems to us an entire mistake. The sole agency in the drainage of land is the weight of the water in the soil, which ensures its passage downwards and outwards, as soon as any channel of escape for it is opened. If the soil be air-tight, so that an air-passage is required to the underground pipe at the upper end of it, still more must it be water-tight, and then, of course, incapable of being drained at all. But no soil is in such a plight as this. It only needs that a channel be cut three or four feet deep in any soil, and any water that is in it will begin to ooze and trickle through it, and thus establish that movement of the rain-water from the surface through the substance of the soil and subsoil which brings all the circumstances of increased fertility in its train.

Among the events of the quarter having an indirect bearing on agricultural subjects, we may mention that the University of Edinburgh has issued a programme of examinations in various branches of applied science, under which students may receive diplomas as Bachelor and Master of Agriculture. There can be no doubt that a successful passage, thus guaranteed, through well-conducted examinations on all the subjects with which a man must be familiar to mark him out as a thoroughly well-educated agriculturist, will ultimately materially affect the future professional career of individual agricultural students; and in this way it will benefit agriculture and agriculturists generally. Professor John Wilson, of the Edinburgh University, has done good service to the cause of general agricultural progress by obtaining at the hands of so distinguished an educational body this recognition of agriculture as one of the professions for which a liberal education is desirable.

We add that the subject of the beet-sugar manufacture and of the sugar-beet cultivation has continued to engage attention. Mr. Gibbs, of Gilwell Park, near Woodford, lately read a paper before the Society of Arts, advocating the use of his drying-engine for the reduction of crop-weight in the field, and the consequent reduction of the expense of carriage, which more than anything else tends to discourage the establishment of local sugar factories. And Mr. Baruchson, of Liverpool, has published a most exhaustive treatise on the agricultural, manufacturing, and commercial aspects of the subject, which ought to be read by every one who is disposed to introduce the cultivation of the sugar-beet upon his farm.

2. ARCHÆOLOGY AND ETHNOLOGY.

The interest attaching to bone-caves yielding remains of man and works of art is still kept at a high pitch by new discoveries. During the past quarter a most interesting account of some explorations in Portuguese bone-caves* has reached us; and we thus obtain evidence that in the district of Cesareda man once existed in so uncivilized a condition that he lived in caves, ate human flesh, and possessed chipped flints for his only weapons. M. Delgado describes three caves in the Jurassic limestone of Cesareda, all of which he has thoroughly explored. In one (the Casa da Moura) he obtained evidence of the existence of two deposits, a lower, resting on the stalagmite floor, composed of sand and angular fragments of the surrounding rock; and an upper, composed of a sandy loam. The lower one yielded many flint implements and fragments of charcoal, with bones of *Felis, Canis, Cervus, Lupus,* &c. In its deepest part the author found a human skull and lower jaw, but these he regards as having been buried at a subsequent period. The upper deposit contained a large number of fragmentary human bones, and numerous polished stone celts, flint flakes, bone instruments, &c., and a bronze arrow-head in its lowest part, which had probably been buried there. The fragmentary condition of the human bones, which had been cut and scraped, the long bones having also been split, appears to show that the author is right in regarding the cave as a burial-place of a tribe of cannibals. Bones of the wolf, fox, a dog, horse, deer, sheep, &c., coarse pottery marked with lines or rows of dots, shells pierced for ornaments, and other objects, were also found. The other caves yielded remains similar to those obtained from this upper deposit, one of them yielding in addition a portion of the lower jar of *Ursus arctos.* If the author's determination of this relic be accurate, it is the most important animal remain which these caves have as yet yielded.

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* Da existencia do Homen no nosso solo em Tempos mui remotos provada pelo estudos das cavernas. Primeiro opusculo. Noticia ácerca das Grutas da Cesareda. Por J. F. D. Delgado.

While on the subject of bone-caves we should notice the publication of the fifth part of the 'Reliquiæ Aquitanicæ.' It contains the conclusion of Professor Rupert Jones's geological sketch of the Vézère, figures and descriptions of a number of flint implements, and a most interesting essay by Mr. A. C. Anderson, "On the Resemblance of many of the Dordogne Works of Art to the Implements used by the North American Tribes, either now or at some former period." This resemblance is in many instances very striking, and suggests two questions for consideration, namely: (1), Are the uses for which the implements were made the same, or analogous, in both cases? and (2), Does the resemblance imply any affinity between the tribes? The first question will probably receive an affirmative reply from almost any antiquary; but the answers to the second would probably show great diversity of opinion. We shall only quote a sentence from Mr. Anderson, as an indication of one class of opinions:—"I believe that, under similar circumstances and conditions of things, isolated branches of the human race will arrive, in simple matters of domestic or offensive art, at nearly similar conclusions, each independently of the other."

Dr. Geinitz has given a useful summary of the objects exhibited in the Paris Exhibition of last year in relation to the Antiquity of Man, in the second number of the 'Neues Jahrbuch' for this year. The reported occurrence of traces of human work in Miocene deposits is not regarded by him as having been yet proved to the satisfaction of critical antiquaries and naturalists.

This question of the Miocene age of the human species was discussed before the Académie des Sciences on April 20th, when MM. Garrigou and Filhol requested the opening of a sealed packet which had been deposited with the Academy by them on May 16, 1864. From this it appears that at that date their observations made in the deposits of Sansan led them to regard the Miocene age of man as extremely probable. The evidence on which they relied consisted of bones split longitudinally, as they are frequently found in caverns, having been thus broken by man for the purpose of extracting the marrow. The evidence is slender; hence, in all probability, their timidity in not publishing their views four years ago; but now that other evidence, more or less questionable, pointing in the same direction, has been discovered, they have naturally regarded their own observations as equally worthy of publicity.

In the last volume of the 'Proceedings' of the Asiatic Society of Bengal we notice a paper on the Ethnology of India, by Dr. J. B. Davis, in which that author strives to show that philology is not so sure a guide in Ethnology as craniology; consequently he is led to object to the Aryan hypothesis. "If Europeans and Hindoos be of the same family, why cannot the former migrate to and live in India? How is it that the people of India are celebrated for the smallness of their heads, while the inhabitants of Europe have large heads?" Again, he remarks that it is admitted that the Syro-Arabian division of mankind is physically identical with the Aryan section; still the two cannot be allied, because the languages of the two families utterly sunder them." In all probability, as Mr. Blanford remarked at the reading of the paper, a natural classification must be arrived at by the aid of a number of characters, as in Botany. Dr. Davis also objects to the hypothesis of the unity of the human race, regarding our species as, "in the main, an aggregate of families formed by the hand of the Creator, in every different locality in which it is found, and each constituted by that wise Providence for the climate and productions with which it is surrounded."

We also notice a series of admirable notes on the occurrence of chipped flakes of agate, quartzite, flint, &c., in India, followed by a table in which all the information on the subject is shown at once. The implements are divided into the three following classes:—

A. Cores and flakes of agate, flint, &c.
B. Chipped axes, &c., chiefly of quartzite.
C. Polished 'celts' of trap, chert, jade, &c.

These objects are extensively distributed, not only in India itself, but also in some of the islands of the Indian Ocean.

With respect to the antiquity of man in India, Mr. W. T. Blanford expresses his belief that there is evidence of the existence of man in India at a much earlier period than in Europe. Unfortunately the "evidence" consists of but one flake found *in situ* in the Godavery gravels by Mr. Wynne. Now the fauna of the Godavery gravels consists of animals having European or African affinities, while the recent fauna has Malay relations; therefore they differ much more widely than the Pleistocene animals of Europe do from those now existing on the continent. If, therefore, we accept the flake found by Mr. Wynne as conclusive of the existence of man in India during the deposition of the Godavery gravels, this conclusion as to the relative antiquity of the periods, though a little crude, is legitimate enough.

We should mention that, in addition to Mr. Blanford, the following gentlemen have contributed their notes to this highly interesting series, Mr. King, Mr. Wilson, and Mr. Ball.

A second supplement to the 'Recueil d'Antiquités Suisses' was published last year by the Baron de Bonstetten, and contains sixteen large folio plates of the objects recently discovered, with a few remarks in explanation of them. The list embraces almost every description of object, from implements of the Stone age found in the lake-dwelling of Greng (lake of Morat) to mosaic pavements and various relics of still later date.

In a letter to M. Lartêt, published in the 'Bibliothèque Universelle' for March, M. Favre has recorded the discovery of a human station of the Stone age, in which remains of the Reindeer have been found, in a small elevation (monticule) at Veirier, at the foot of Mont Salève, not far from Geneva. Hitherto remains of the Reindeer have been found in the terrace-alluvium in but five localities in Switzerland, namely, at three places on the Lake of Geneva, at Meilen on the borders of the Lake of Zurich, and at Windisch on the Reuss. With the Reindeer occur remains of the Horse, Ox, *Cervus elaphus*, *Lepus variabilis*, *L. cuniculus*, the Marmot, *Meles taxus*, the Ptarmigan, the Sheep or the Bouquetin, human bones (fragments of skull, &c.), small worked flints, and various other examples of human workmanship. These remains were found at a height of 42 mètres above the present level of the river Arve, and it seems clear that since the glacial period the water of the river has reached to a height of 38 or 40 mètres above its present level. M. Favre believes that the mound was inhabited by man when the water of the river was at a higher level than it now attains, though probably not when it was at its highest; and M. Lartêt expresses his opinion, in a reply to M. Favre, that the Reindeer period is probably not of the same age, but somewhat more ancient, in southern Europe than in more northern latitudes, the animal having migrated northwards.

The 'Report of the Proceedings of the Geological and Polytechnic Society of the West Riding of Yorkshire' contains a very readable and interesting paper by the Rev. Canon Greenwell, "On the Inhabitants of Yorkshire in Pre-Roman Times," which is chiefly occupied with a description of the manners and customs of "the ancient Briton," so far as they can be inferred from the implements, ornaments, tombs, monuments, &c., which the researches of archæologists have brought to light.

The same volume contains a description of a Romano-British mosaic pavement, representing Romulus and Remus, discovered at Aldborough (Isurium of the Romans), by Mr. Henry Ecroyd Smith.

The 'Reliquary' for April contains a short note by Mr F. C. Lukis, reminding us that the now well-known Stone Celt and Flint Arrow-head were formerly regarded in the north with considerable superstition, the latter being known as the Elf-Shot, while the larger examples were designated Elfin Darts. As usually happens in such cases, the same objects which in one district are highly prized as preventive of evil, are in others shunned as producers of misfortune.

Mr. Peacock gives an account, in the same number, of the opening of a Celtic grave-mound, at Cleatham, Lincolnshire; and the editor, Mr. Llewellynn Jewitt, gives a description and figures of the urns. The excavation has been chiefly interesting as showing the manner in which these barrows were made. "When a section of the hill was made, it became quite evident that the whole of this large hill had been carried where it was in baskets. Each basket-load was distinctly visible." Mr. Peacock remarks that, although antiquaries have long known that this must have been the mode of accumulation, "this is, perhaps, the first instance where ocular demonstration of the fact has been given."

Mr. T. M'Kenny Hughes has commenced in the 'Geological and Natural History Repertory and Journal of Pre-historic Archæology and Ethnology' for May, a useful paper on flint implements, in which he endeavours to define the distinctions between the natural forms of flints and those which have been produced artificially. Premising that the natural forms of flint are derived, 1st, from the original formation of flint in the chalk; 2nd, from fracture; and 3rd, from weathering; the author describes the nature of these natural appearances, and insists on the truth of Mr. Evans's canon, that the only kind of evidence of the human origin of manufactured forms which can be admitted is that of design shown in various ways. This paper will be specially useful as containing a descriptive catalogue of a collection of implements in the Museum of Practical Geology, Jermyn Street, classified in series to illustrate the several categories to which various implements may be assigned.

In the same number the editor, Mr. Mackie, describes and figures a very singular chipped flint in the shape of a flattened sphere, which was found at Willesden by Mr. Caspar Clarke. Unfortunately, the circumstances under which it occurred are not stated. Its use Mr. Mackie is uncertain about. From the drawings we should infer that it might have made a tolerable hammer.

The 'Anthropological Review' for April contains nothing that demands notice from us except a partial report of the proceedings of the Congress of Pre-historic Archæology which was held at Paris last year. Certain questions were proposed for open discussion; but of course we cannot give in this Chronicle even an outline of the facts and opinions advanced in illustration of them. With respect to caverns, however, we learn from the 'Anthropological Review' that it was agreed that they should be divided into three classes, namely, (1) those which contain the Quaternary fauna, now utterly extinct; (2) those in which the Reindeer assumes a large development; and (3) the caverns which contain only the animals now found in the country, many of which had been no doubt domesticated. We also learn that it was generally admitted that cannibalism was practised in pre-historic times down to the period of polished stone. Other questions related to the antiquity of man, the megalithic monuments and their builders, the Bronze age, the Iron age, and the anatomical characters of Pre-historic man. On the last question, apart from minor differences of opinion, there was some amount of agreement that there were two races of Pre-historic men, one brachycephalic and the other dolicocephalic. M. Pruner-Bey, however, preferred describing the former as characterized by a lozenge-shaped face and the latter by an oval-shaped face.

This year the Congress will be held at Norwich, commencing on August 20th, under the presidency of Sir John Lubbock, Bart., F.R.S.

3. ASTRONOMY.

(Including the Proceedings of the Royal Astronomical Society.)

The re-discovery of Brorsen's comet is the most interesting astronomical occurrence of the past quarter. This comet must not be confounded with another—also called Brorsen's comet—which revolves in a much more extended orbit. The comet just discovered belongs to that remarkable family of comets of which Biela's, De Vico's, and other objects are members. All the comets of this family—in other words, all the comets of short period—have the aphelia of their orbits pretty close to the orbit of Jupiter. It seems probable that the introduction of these comets within the solar system—or at least to their present position in that system—is due to the action of this great planet. This is certainly the case with Brorsen's comet; since D'Arrest has shown that before 1842 it had been moving in an orbit of very different figure. In that year it passed very near to Jupiter, and was compelled by his attractive influence to travel in its present orbit. Discovered in 1846, the comet was missed at the perihelion passage of 1851, seen in 1857, again missed in 1862, and re-discovered, by three observers almost simultaneously, in April of the present year. It will travel across the southernmost parts of the constellations Ursa Major and Bootes, remaining throughout invisible to the naked eye.

Mr. Huggins has subjected Brorsen's comet to spectroscopic analysis. The results are exceedingly interesting. It will be remembered that two former comets, examined by Mr. Huggins, exhibited, so far as the light of their *nuclei* was concerned, spectra closely resembling those of the gaseous nebulæ. Their *comæ* appeared to shine by reflected light. The spectrum of the present comet is very different. It consists of three bright bands, somewhat resembling those seen by Donati in the spectrum of the comet which bears his name. The length of the bands shows that they are not due to the steller nucleus of the comet alone, but are produced by the light of the coma, or at least of its brighter portions. In one of the bands Mr. Huggins could occasionally detect two bright lines, shorter than the band, and therefore presumably due to the nucleus alone. This view of their origin was confirmed by the circumstances that they were not visible when the middle of the comet was not upon the slit, whereas the nebulous band on which they were projected continued visible so long as any part of the comet except its extreme margin was upon the slit. A very faint continuous spectrum was also visible. The brightest band was found to lie nearly in the same position as the brightest line of the nebulæ, which is coincident with the double line in the spectrum of nitrogen.

It appears, then, that Brorsen's comet resembles the two others (and probably Donati's) in this respect, that the nucleus and part of the coma shine by their own light. But whereas only the brightest part of the comæ of the two other comets shone by their own light, it appears that nearly the whole of the coma of Brorsen's comet is self-luminous.

We have to record a most interesting application of spectroscopic analysis to a different subject of astronomical research. It is well known that what is called the proper motion of the stars, or their apparent change of place on the sidereal concave, is in reality only a portion of their true motion—the *transverse* portion. The other part—or the motion of a star directly towards or from the eye—produces no effects perceptible by the telescope. It would require thousands of years before any motion of this sort could produce an appreciable change in a star's apparent brilliancy; but by a subtle application of spectroscopic analysis, Mr. Huggins has led the way in a process of research which promises to afford us information respecting this part of the stellar motions. The law on which the inquiry proceeds may be thus illustrated:—If we imagine a powerful swimmer to urge his way rapidly against a series of advancing waves, it is evident that they will pass him more rapidly —in other words, they will seem narrower—than if he were at rest; on the contrary, if he urged his way in the same direction as the waves, they would appear broader than they really are. Since the light of the stars reaches us in a succession of minute waves, it is clear that if we are approaching a star or receding from it, whether through the earth's motion or that of the star, the light waves will appear modified in length—in other words, the light's refrangibility will be altered. Thus the lines in the star's spectrum will be altered in position, and will no longer coincide with the corresponding lines in the spectra of terrestrial substances. Our space will not permit us to enter into an account of the methods which have been devised to enable spectroscopic analysis to deal with this very delicate research. At present we must content ourselves with exhibiting the two principal results of Mr. Huggins's labours. He has succeeded in showing that the nebulæ are not approaching the earth or receding from it at a rate which is appreciable by his instruments; but he finds that the bright star Sirius—the only fixed star which he has yet had time to examine satisfactorily—is approaching the solar system at the rate of nearly 29½ miles per second.

Mr. Huggins has re-examined the spectra of several nebulæ. He finds that when the intensity of the spectrum of nitrogen is diminished by removing the induction spark in nitrogen to a sufficient distance, the whole spectrum disappears except the double line, which agrees in position with the bright line in the nebulæ. "It is obvious," he adds, "that if the spectrum of hydrogen were greatly reduced in intensity, the strong line in the blue, which corresponds to one of the lines of the nebular spectrum, would remain visible after the line in the red, and the lines more refrangible than F had become too feeble to affect the eye." We shall see presently that this view has been confirmed by an experiment made by Father Secchi. There seems reason for supposing that the light of the gaseous nebulæ is emitted by nitrogen and hydrogen.

Mr. Huggins has also been able to confirm the observations made by Mr. Lockyer on the spectra of the umbræ and penumbræ of solar spots, and to obtain some new results of interest. He found that most of the dark lines of the solar spectrum were wider in the spectrum of the umbræ. The lines F and C due to hydrogen were not stronger, however. No new lines were detected, nor were any of the lines of the normal solar spectrum wanting in the spectrum of the umbra.

We hear that Mr. Lockyer is about to renew his observations of the solar spots with a spectroscope specially prepared for the purpose by Mr. Browning.

The last-named gentleman is also preparing a powerful spectroscope for use with the great Parsonstown reflector. The Earl of Rosse, following worthily in the footsteps of his father, is about to apply the unrivalled light-gathering powers of this instrument to the spectroscopic analysis of objects too faint to be reached by smaller telescopes. Clockwork is to be so applied to the great telescope, so that it will follow stars and nebulæ as closely as a smaller equatorial would.

Our readers will be glad to hear that the instruments supplied by the Royal Society to the expedition under Lieutenant John Herschel have already been applied to useful work—six nebulæ in the southern hemisphere have been examined with the spectroscope. The great nebula in Argo is found to exhibit a spectrum of bright lines, so that, like its rival in splendour the great Orion nebula, this object is gaseous.

The great eclipse of August 17th will be well watched. Besides the expeditions sent out under Lieutenant Herschel and Major Tennant, there is to be one under the charge of Mr. Pogson, the Government astronomer at Madras; another has been sent out by France under M. Jansen; the Papal government sends out Father Secchi, and there is also to be a Prussian expedition. Mr. Huggins has sent out to Mr. Pogson a spectroscope and apparatus for observing polarization.

The Minister of Public Instruction in France has lately submitted to the Council of State the draft of a decree for the complete reorganization of the Imperial Observatory at Paris. It is stated that this establishment will be removed from its present site, which is very unfavourable for astronomical observation, owing to the vibration of the building caused by passing vehicles. The air also in the neighbourhood of the Observatory is so heavily loaded with smoke and vapour as to interfere with many of the delicate observations which have to be made by astronomers of the present day. We learn that owing to these causes it is impossible to apply a higher power than 500 to the great equatorial. It is proposed to remove the Observatory to Fontenoy-aux-Roses, south-west of Paris.

The planet Venus is now very favourably situated for observation. She has been seen several times in full day-light. Mr. Browning has observed several faint markings on the planet, resembling the grey plains on the moon. "These markings seem to be studded with white spots of various sizes." It is a pity that modern astronomers do not make an effort to learn something respecting the axial position of Venus. Large achromatics do not seem well suited to this work, on account of the extreme brilliancy of Venus.

Reflectors used with a solar eye-piece containing a simple surface-reflecting prism, seem to give the most satisfactory views.

The ninety-eighth asteriod was discovered by Mr. Peters, at Clinton, on April 18th last; it is of the twelfth magnitude.

The lunar crater Linné continues to be a subject of dispute in the astronomical world: the opinion is gaining ground that there has been no change in the crater, but that, owing to the peculiar character of the moon's surface in this neighbourhood, very slight variations in the illumination serve to produce marked variations in the appearance of the crater. At a late meeting of the Astronomical Society, Captain Noble stated that a "few hours sufficed to change a distinct ring into a *smudge*."

Saturn is now an interesting object of observation, though his southern declination is unfavourable to distinctness. His rings are well open, the outer edge very nearly coincident (in appearance) with the outline of the ball. It is to be hoped that something may be learned respecting the structure of the rings during the present and the next two oppositions, as some fourteen or fifteen years will elapse before the rings are again opened to their full extent.

PROCEEDINGS OF THE ROYAL ASTRONOMICAL SOCIETY.

M. Hoek, director of the Observatory of Utrecht, remarks on the small distance which separates the intersection of the orbits of comets III. and V., 1857, from the point which he has assigned as the radiant point of cometary orbits. Comet III., 1867, unexpectedly confirms his views, since, as we have mentioned in a former Chronicle, the circle which is the intersection of its orbit-plane with the celestial sphere passes through almost the same point of the sky. Thus, he adds, "the last ten years have furnished us with two Cometary systems, each composed of three members; first, that of the years 1860 and 1863, then that of the years 1857 and 1867. It appears that it would be to mistake the principles of the theory of probabilities, if we attributed all these coincidences to mere chance."

He supplies also an elaborate memoir on the phenomena which a very extended swarm of meteors, coming from space, would present after its entry into the solar system. He takes the case of a swarm of corpuscles coming from the stellar spaces, and sufficiently extended to embrace the whole earth. It would be impossible in the space available to us to give even a sketch of the processes applied by M. Hoek, which occupy no less than eighteen pages of calculation. Some of the results at which he arrives agree closely with those lately published by M. Schiaparelli, in a memoir entitled "Note e Riflessioni intorno alla Teoria Astronomica delle stelle cadenti." M. Hoek finds that under certain circumstances, the earth's attraction may have the effect of shifting the radiant point more than 17°. In future therefore it will be necessary to note the hour and the minute of each observation made on a falling star.

Sir John Herschel has been engaged, since he sent to the Astronomical Society his synoptic catalogue of stars observed by Sir William Herschel, in forming a general digest of all the recorded measures of all known double stars—a task which "he hopes to leave in such a state of forwardness as will ensure its completion by some other hand." While engaged on this task, he has been led by the coincidence, or near coincidence, of the measures taken by Sir William with those of stars observed by others, to the identification, more or less probable, of a considerable number of these stars with those subsequently measured. He supplies a list of the objects in question, judging "that information of this kind cannot but prove interesting to observers engaged in the measurement of double stars." In the progress of the work he has been led to the detection of a somewhat formidable list of errata in the printed catalogue. We should recommend those who possess or make use of the catalogue to pay attention to these errata, some of which are important, and, if uncorrected, likely to cause the observer considerable waste of time.

Mr. Key supplies an interesting paper on the planetary nebula 45 ♅ Geminorum. This nebula was discovered by Sir W. Herschel in 1787, and is described by him as "a star of the ninth magnitude, with a pretty bright nebulosity equally dispersed all round." The younger Herschel describes it as "a star of the eighth magnitude, exactly in the centre of an exactly round bright hemisphere 25″ in diameter." Lord Rosse gives an account of the same object in the 'Philosophical Transactions,' 1850. He saw it as a nebulous star with a black patch close to it on the preceding side, a less luminous space somewhat unequal in breadth surrounding the nucleus, and a luminous ring at some distance; this ring being of less breadth on the following side. Mr. Lassell's drawing of the object, in 1862, represents a star in the centre of a planetary disc, surrounded by a non-luminous space, and, at some distance, by a luminous ring of considerable breadth. He adds that "he can see no trace of the dark patch of Lord Rosse's drawing near the bright centre." Mr. Key, using an 18-inch silvered-glass reflector 10 feet in focal length (of his own make), finds the present appearance of the object to be different. It appears as a bright but somewhat nebulous star, closely surrounded by a dark ring; this again is surrounded by a luminous ring; then comes an interval much less luminous, and finally, at some distance, an exterior luminous ring. The whole is almost exactly symmetrical, though not quite so; the dark space between the two bright rings being darker on the north following side, and the preceding side of the whole object is rather fainter than the rest. Of the two luminous rings the inner is considerably the brighter.

Mr. Key considers that there is a progressive character in the results above recorded, since the various aspects of the nebula do not appear to depend on the power employed. His own reflector is somewhat more powerful than the Herschelian 20-feet reflector, but is of incomparably inferior power to the instruments of Lord Rosse and Mr. Lassell. "One fact," he adds, "seems, at all events, abundantly evident, *viz.* that whereas at the date of the Herschels' observation, there was no appearance whatever of a ring surrounding the central star, at the present time there are two."

Mr. Simms supplies a description of a zenith telescope employed in America, and explains a method of determining the latitude which has been for several years adopted by the United States coast surveyors, and which has the advantage of being at once simple and exceedingly accurate. The instrument is further described, and figured in a later number of the Society's notices, in a paper by Mr. Davidson, of Germantown, Pennsylvania. The method of observation, known as Talcott's, is worth studying:—"Two stars are selected, one of which passes the meridian to the north, and the other at nearly the same distance to the south of the zenith. The telescope is brought into the plane of the meridian, and set for the star which first passes the meridian; when visible it is bisected by the micrometer wire, the tangent screw of the instrument being used. The telescope is then turned 180° in azimuth, and when the second star makes its appearance, should there be any difference in the zenith distances, this distance is measured by the micrometer screw." The latitude is readily deduced. For example, suppose the polar distances of the two stars are D and D′ (D less than D′), and that the former star, when on the meridian, has a zenith distance less than the corresponding zenith distance of the other by a small arc d; then a star, whose polar distance was $D-d$, would cross the meridian at exactly the same altitude towards the north, as the star whose polar distance is D′ has towards the south. Hence the polar distance of the zenith of the place of observation, that is, the complement of the latitude, is $\frac{1}{2}(\overline{D-d}+D')$. Mr. Davidson says that, after twenty-two years' experience in using prime vertical transits, vertical circles, and Airy's zenith sector, he can affirm confidently that the zenith sector of the coast survey, used as above described, is far better than any of them.

Father Secchi supplies an interesting paper on the great nebula in Orion. He has also sent to the Astronomical Society a drawing of the nebula, commenced several years ago, and finished last year by combined observations made by himself and Father Ferrani, his assistant. One point in Father Secchi's paper will excite surprise. He states that the nebula is much better seen in moonlight than on dark nights. He considers that this is a consequence of that optical principle, that the difference of two lights is more easily appreciated when they are weak than when both are strong. He finds that, as Mr. Huggins had anticipated, the spectrum of hydrogen may be made, by sufficiently diminishing the light, to present the middle line only, which is that visible in the nebula.

Mr. Stone supplies a valuable paper on the rejection of discordant observations. His theory is that the rejection of such observations cannot be made except upon a direct admission of carelessness on the part of the observer; and he shows how the amount of error which justifies a rejection is to be calculated from an estimate of the average number of mistakes made by the observer in a given number of observations.

Mr. Chambers supplies a catalogue of binary stars formed (in the main) by reducing to the year 1870 the stars in the excellent catalogue presented by Mr. A. Brothers, to the Manchester Literary and Philosophical Society.

Mr. Proctor puts forward a proposal for a new star-atlas. The advantages of the plan appear to be the following:—The stars would be presented in a moderate number (12) of maps, uniform in size, shape, and mode of projection; with scarcely appreciable distortion and scale-variation; not too large for convenient use (about 12 inches in diameter), and yet on the sufficiently large scale of an 18-inch globe. The twelve maps would correspond to the twelve pentagonal maps of his gnomonic set, but being made circular and thus overlapping, the connection between the different maps would be conveniently exhibited.

We must leave to our next number the review of several interesting papers which appear in the latest number of the Society's Proceedings. The issue of this number having been delayed for the completion of a lithograph, illustrating Mr. Abbott's paper on certain variations in the nebula surrounding η Argûs, we have received the number too late for discussion here. But we are glad to notice that there now occurs less delay than took place some few months ago in the issue of the Society's notices.

4. BOTANY AND VEGETABLE PHYSIOLOGY.

Green Rotten Wood.—We have received the following from Mr. H. C. Sorby, F.R.S.:—"In the last number of your Journal (p. 222) you call attention to the colour of green rotten wood, and ask whether it has any relation to the Phycocyan of Cohn. I have examined it carefully, and find it is quite distinct from that or any other colouring matter with which I am acquainted. The chief constituent is a green-blue colour, insoluble in water and only sparingly soluble in alcohol or benzole, and not fluorescent; whereas Phycocyan is soluble in water and very fluorescent. The spectra are also quite different. It gives merely one absorption band very near the extreme red; whilst Phycocyan gives two, both much farther from the red end. In its general characters it is related to chlorophyll, but is quite distinct from it. The wood also contains two yellow colours, which make it more green; and also a substance of a claret colour, which seems to make it somewhat dull. This claret colour is insoluble in water, but much more soluble in alcohol than the green-blue; and is quite different from any other substance which has come under my notice. On the whole, both these colours are very interesting, since they belong to classes of colouring matters which are so rare that I only know one or two other examples out of some hundreds which I have examined and classified."

Nature of "Leaves" of Sciadopitys.—At p. 124 of the 'Report of Proceedings' of the Botanical Congress in 1866, Professor Dickson pointed out that the linear leaf-like bodies in *S. verticillata* were homologous with branches, and analagous to the phylloid shoots in Ruscus, Phyllocladus, &c. His views have been confirmed by the observations of M. Carrière, published in the 'Revue Horticole,' who has seen them bearing buds, and also branched and whorled.

Stamens of Cochliostema.—Dr. Masters has described in the 'Gardener's Chronicle' the structure of the andrœcium in a species (*C. Jacobinianum*, Koch and Linden) of this hitherto misunderstood genus of Commelynaceæ. On removing the leaves of the perianth, in front of the flower appear two lateral linear purple organs densely clothed with fringe-like hairs; these are considered staminodes, or abortive stamens. The perfect stamens present a very unusual appearance. A single organ arises from the posterior part of the flower, and attached to its base behind is a dense tuft of yellow hairs. The organ consists below of a flat stalk, but above of two petal-like convolute horns with long terminal points. This was formerly considered a single stamen, but is now seen to be three combined. The anthers are entirely enclosed in the cavity of the organ, and are three in number; two being vertical, attached by slender filaments to near the inner edge of the petal-like process; and the third horizontal, below the other two, its filament bent downwards: at the back of the organ, at a point corresponding to the attachment of this anther, is an oval disk surrounded by a few irregular processes. The anthers are twisted into a spiral, and dehisce by a line which follows all the curves. The theoretical nature of this andrœcium is considered by Dr. Masters to be nine stamens in three rows (or, if the staminodes be considered petals, six in two rows). The outer row is barren, consisting of the two lateral purple organs and the tuft of yellow hairs; of the stamens of the middle row, only the posterior two are developed, their anthers being the two vertical ones, and part of their filaments dilated into the petal-like horns; of the inner whorl only the posterior is developed as the horizontal anther.

Seeds of Juncus and Luzula.—In the 'Botanische Zeitung' is a paper by Dr. F. Buchenau, of Bremen, "On the Sculpture-markings of the Testa of the Seeds in the German Species of these Genera." An English translation appears in Seemann's 'Journal of Botany' for May. Certain points of difference connected with the seeds have long been used as sectional characters in both genera; but the peculiar mouldings of the external seed-coat do not seem to have been systematically examined by any botanist before Dr. Buchenau. At his suggestion, however, Dr. Engelmann of St. Louis looked at this point in the North American species of Juncus, and in his recently published "revision" of them* has founded three sections on the characters presented. In the present paper, Dr. Buchenau, though taking exception to some of Dr. Engelmann's terms, generally adopts his divisions. The characters of the testa of 31 species of Juncus are given as seen under a power of 50 diameters in *dried herbarium specimens* of *perfectly ripe* seeds. It appears that the testa is either *costate*, *i.e.* marked with prominent longitudinal ribs, connected only by few and inconspicuous ones, or *reticulate*, of which there are two kinds. In one the costæ are still prominent, but connected by equally prominent transverse ridges, in the other the costæ are inconspicuous and wavy or angular, whilst the transverse ribs appear very prominently (called *transtilla*); in both cases reticulations are formed, and are often marked with more delicate lines (*lineolæ*). The characters are said to be constant.

In Luzula there is less variety, the testa being reticulate in a more or less regular or longitudinal manner in all the species (12) examined.

Seedless Raisins.—Mr. T. Meehan, in the 'Proceedings of the Philadelphia Academy,' calls attention to the fact that the ordinary vine of Europe is frequently found in a barren state, bearing only male flowers, and he suggests that the seedless raisins and currants so much prized may be the fruit of purely female plants, ripened, though never fertilized. It appears, however, that as yet purely female plants have never been observed by botanists.

Discoloration of the Sea.—Some interesting facts "On the Nature of the Discoloration of the Arctic Seas" were communicated last year to the Edinburgh Botanical Society by Mr. Robert Brown. The paper has been printed in Seemann's 'Journal of Botany.' Arctic voyagers have long ago noticed the sea in Davis's Straits, Baffin's Bay, and other parts, to be dark olive-green, or even black in colour, and the appearance has been considered to be due to the presence in it of great multitudes of minute animals (*Medusæ*, *Entomostraca*, and *Pteropoda*.) Mr. Brown noticed, however, that though these animals often sunk, the water still in their absence retained its peculiar colour. On further examination he found the cause of this to be a vast abundance of *Diatoms*, chiefly of one moniliform species, the name of which does not appear to have been determined. The *Medusæ* and other animals were found to feed on these plants, and, as is well known, are themselves the food of the whale, hence the presence of those vast cetaceans in the "black water." The same *Diatom* (with others) is the cause of the brown "rotten ice" of explorers; but this fact has been previously noticed by Dr. Sutherland.

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* 'Transactions of the Academy of Sciences of St. Louis.'

A paper by Dr. C. Collingwood on the same subject, read at the Microscopical Society in March, appears in the 'Microscopical Journal.' In this the cause of the coloured water in the Indian ocean and China sea is investigated; as in the former case, it is due to a minute *Alga*, not a *Diatom*, but referable to *Trichodesmium*, a genus of *Oscillatoriæ*. The appearance produced on the water is that of a yellowish-brown scum, the sailors call it "sea-dust." The plant consists of short filaments, composed of a single line of cells, combined into a cylindrical unbranched fibre. A good many of these are aggregated into little bundles, having the appearance either of a "sheaf" or a "wedge," according as they are in close contact either at the middle or at one end. A species of *Oscillatoria* (?) occurs with it. Dr. Collingwood has never seen any *red* discoloration of the sea, such as is said to have been observed by many persons in the Red Sea and Persian Gulf, and also in the North Pacific, and which is caused by one or more closely allied species of *Trichodesmium*.

Hederaceæ.—Dr. Seemann gives another instalment of his revision of this order in the May number of the 'Journal of Botany.' *Kissodendron*, *Didymopanax*, *Aralia*, and other genera are passed in review; and the characters of two new genera *Dipanax* and *Triplasandra* are defined. The author however appears to have a tendency to create genera in this order on somewhat slender grounds.

British Botany.—The curators (Mr. Baker and Dr. Trimen) of the London Botanical Exchange Club have published their annual Report for 1867. Three new plants are described: *Rosa Hailstoni*, Baker (a variety of *R. canina*), from Yorkshire; the true *Allium carinatum*, Linn., from Nottinghamshire; and *Salix Grahami*, Borrer, from Sutherland. The Report includes notes on the numerous interesting or rare species, native and introduced, which have been communicated to the Club during the year.

The recently discovered *Viola Arenaria*, D.C., is recorded by Mr. James Backhouse from a new locality "several miles distant" from the only previously known one in Teesdale, Durham.

A *Carduus*, said to be new to Britain, has been gathered in Rossshire; from the description given it appears to be one of the many hybrid thistles already known. Specimens were shown at a late meeting of the Edinburgh Botanical Society.

M. Mitten adds to our Flora a new Moss, *Trichostomum flavo-virens*, Bruch and Müller. It was found on Shoreham beach, Sussex. A figure and description will be found in the 'Journal of Botany' for April.

New Books.—The Ray Society has published the second and concluding volume of *Robert Brown's works*, edited by Mr. Bennett.

'The Chinchona species of New Granada,' by Clement R. Markham, with notes by J. E. Howard, has been published by the India Office. It contains the hitherto unpublished descriptions of the species distinguished by Mutis, the celebrated Spanish botanist, which have been since 1807 kept at the Botanic Gardens, Madrid; and also those of Dr. Karsten, originally published in German.

The long-expected 'Flora of Northumberland and Durham' by Mr. Baker and Dr. Tate, is printed and forms vol. ii. of the 'Natural History Transactions of Northumberland and Durham.'

'Refugium Botanicum' is the title of a new periodical, edited by W. W. Saunders. It consists of figures and descriptions of little known or new plants of botanical interest. The plates are drawn by Fitch from living specimens in Mr. Saunders' collection, and the descriptions are by Mr. Baker of Kew. This first part contains 24 plates, chiefly of succulent and bulbous plants, many being South African. The smaller orchids are promised, and Professor Reichenbach of Hamburgh will describe them.

The first part of vol. xxvi. of the 'Linnæan Society's Transactions' has been issued. In Botany it contains a monograph of the Bamboos by Colonel Munro; an account of the geographical distribution of all known ferns by Mr. Baker; and a few other papers of less interest.

Dr. Milde has published in the 'Botanische Zeitung' his *Index Osmundarum*, with remarks on the fructification of the genus.

Botanical News.—A paper by Mr. Darwin "On the Specific Differences between Primula veris, P. vulgaris, and P. elatior, and on the hybrid nature of the Common Oxlip, with supplementary remarks on naturally produced Hybrids in the genus Verbascum," was read at the Linnæan Society's Meeting, March 19th.

A new part of 'De Candolle's Prodromus' is nearly ready. It contains monographs of *Salicaceæ* by Professor Andersson of Stockholm, and of *Coniferæ* by Professor Parlatore of Florence.

A 'Flora of Gloucestershire,' by Dr. G. O. St. Brody, is announced as preparing for publication.

Mr. Marmaduke A. Lawson of Cambridge has been appointed lecturer on Botany at St. George's Hospital, *vice* Dr. Masters, resigned.

5. CHEMISTRY.

(Including the Proceedings of the Chemical Society.)

The memoirs on subjects relating to pure and applied chemistry which have appeared during the last quarter are so numerous, that we shall be obliged to confine our notices under this heading to such discoveries as are likely to prove of commercial importance or are of especial scientific interest. Foremost amongst researches which are likely to benefit mankind we may place those which have for their object the discovery of a cheap method of preparing oxygen gas. Two processes having this object in view have lately been brought before the public. The first is by M. Gondolo, who has made some improvements in M. Boussingault's process of extracting oxygen from the air by means of baryta. M. Boussingault, in 1852, found that on passing a current of air over baryta, heated to dull redness, oxygen was subtracted from the air, and binoxide of barium formed, and that upon then raising the heat to bright redness the oxygen was set at liberty so easily that it might be first absorbed and then evolved *ad infinitum*. M. Gondolo has made, in carrying out the detail of the process, certain changes which admit of oxygen being prepared upon a manufacturing scale. For the porcelain tubes he substitutes iron ones, which may be made either of wrought or cast iron. Internally a coating of magnesia is applied, and externally asbestos, so as to diminish the porosity of the tube and the consumption of fuel. These tubes are arranged in a brick furnace having dampers, by means of which the temperature may be changed at will, and dull redness and bright redness easily obtained. To the baryta a mixture of lime, magnesia, and a small quantity of manganate of potash is added; this prevents fritting of the material. M. Gondolo says that he has made 122 alternate operations, and that the atmospheric oxygen and nitrogen are easily separated upon an industrial scale; the apparatus has been at work during six months, and fulfilled its purpose thoroughly.

The second method by which cheap oxygen can be procured is due to M. Mallet, who has just communicated to the Academy of Sciences an additional memoir in explanation of a process which he published last year. This depends upon the fixation of the atmospheric oxygen upon protochloride of copper forming oxychloride, which again gives out its oxygen at a higher temperature. The absorption of oxygen by protochloride of copper is spontaneous; the air being ordinarily moist, it will be complete in a few hours, if fresh surfaces be renewed. But elevation of temperature, and this is a main point, induces a much more rapid absorption: at temperatures between 100° and 200°, as well as at higher temperatures in the presence of water, this absorption may be considered as almost instantaneous. By this process 100 kilogrammes of cupreous chloride, usually mixed with inert matter for convenience, will yield 3 to $3\frac{1}{2}$ cubic metres of oxygen, and as four or five operations may be made in four-and-twenty hours, this quantity, 100 kilogrammes, would yield 15 to 18 cubic metres of oxygen during the same time: the price of the chloride of copper does not exceed 1 franc the kilogramme.

A new method of preparing magnesium has been devised by M. Reichert. He takes 1,000 grammes of the anhydrous double chloride of magnesium and potassium, pulverizes it, and mixes it with 100 grammes of finely powdered fluor spar; this mixture is fused with 100 grammes of sodium. The compound proposed for use occurs in the mineral kingdom in tolerable abundance as *carnallite.* White pieces of this mineral are available, and require no previous treatment; coloured fragments must be dissolved in water, the impurities allowed to settle, and the lixivium evaporated.

Professor Gamgee, President of the Albert Veterinary College, author of several works upon the cattle plague, and a recognized authority in such matters, has discovered a new process for preserving meat, which is simple and inexpensive. The animal is caused to inhale carbonic oxide gas. Before it is quite insensible it is bled in the usual way. When dressed the carcase is suspended in an air-tight receiver, the air exhausted, and the receiver filled with carbonic oxide gas; a small quantity of sulphurous acid gas is also added. After remaining here for from 24 to 48 hours, meat may be removed, and hung in a dry atmosphere; it will keep for one, two, or three months, or longer, with no perceptible change in taste or appearance. The tests of the method thus far applied have been attended with success. Beef killed in London in March last year was sent to New York in June, and as late as the middle of July was shown to a prominent butcher in Fulton market, who did not discover that it was other than ordinary beef, and expressed the opinion that it had probably been killed about two days. Mutton killed in London last July, and sent to New York soon after, arrived perfectly fresh; and one piece of beef kept for ten days in a can surrounded by water at a temperature of 90° to 100°, came out perfectly fresh. The process, in the opinion of eminent chemists, does not injure the meat in the least; this is an advantage very difficult of attainment, even in the case of transportation of live stock, which is liable to the bad effects of confinement and the length of the journey. Among the beneficial results of the adoption of this scheme would be a better supply in our markets of wholesome meat and at a desirably cheaper rate.

The extraction of oils by means of bisulphide of carbon is now carried on at Moabit, near Berlin, upon a very large scale. In the manufactory of M. Heyl, 2,570 kilos. of oil, of sufficiently good quality to be employed in lubricating machinery, are manufactured daily. Colza and linseed are the materials chiefly operated upon; the residues serve very well to feed cattle with. The seeds are first crushed and dried by heating. For the daily fabrication of 2,570 kilos. of oil only six men are required. Analysis has shown the residues to contain only 2 per cent. of oil and 7 per cent. of water, while the residues of the ordinary pressure process contain 9 per cent. of oil and 15 per cent. of water. In the extraction of the oil, 7,000 kilos. of bisulphide of carbon are used daily, and the amount lost is 28 kilos.

M. Rakowitsch proposes a method of examining flour by means of chloroform. The following are the results which he says may be gathered from an experiment capable of being made in a few minutes:—The amounts of bran, the moisture between 10 and 25 per cent., the damaged flour, the mineral matters, the ergot of rye, and other impurities. The whole of these are determined by the relative specific gravities of the different substances in chloroform. The flour is simply placed in a tube and mixed with chloroform; the chloroform is enabled to hold in very thorough suspension the pure flour, while the other materials are not thus suspended. By adding spirits of wine of 95°, the flour is precipitated to the bottom of the tube. The more humid the flour, the more spirits of wine must be added, and thus the amount of humidity in the flour is arrived at.

The employment of charcoal filters has long been advocated, on account of the known property of this substance to absorb and oxidize organic matter. Mr. W. Skey, of New Zealand, has now shown that charcoal will remove arsenic from water. If a few drops of a solution of a salt of arsenic, or arsenious acid, be put into a few ounces of dilute sulphuric acid, and the mixed solution agitated at intervals with recently ignited charcoal for an hour or two, the clear liquid obtained by filtration does not manifest any reaction of arsenic when tested by Marsh's process. Tungstic acid also is removed from acid solutions by charcoal applied in like manner, and is given up to a solution of caustic alkali.

PROCEEDINGS OF THE CHEMICAL SOCIETY.

The subject of water analysis still occupies the attention of this society to an extent entirely out of proportion to the merits of the inquiry. At the meeting on March 5th, Messrs. Wanklyn and Chapman read a long paper "On the Action of Oxidizing Agents on

Organic Compounds in presence of excess of Alkali." This paper was in continuation of researches which the authors had brought forward at previous meetings in reference to the estimation of organic nitrogen in water. They now state that an examination of typical substances lead them to the following results:—1. Some bodies yield the whole of their nitrogen as ammonia when treated with alkaline permanganate: of this class are asparagine, piperine, narcoline, and hippuric acid. 2. Some bodies give off *half* their contained nitrogen as ammonia: amongst this class are to be found morphia, strychnine, quinine, nicotine, toluidine, and acetate of rosaniline. 3. One body, creatine, gives off *one-third* of its contained nitrogen. 4. Theine gives off one-fourth of its nitrogen. 5. Other bodies have been found to evolve various proportions of nitrogen: thus, uric acid gives off about 7 per cent. of ammonia; caseine, 7·6 per cent.; and albumen about 10 per cent. This paper was followed by a "Note on Dr. Frankland's Process of Water Analysis," by Mr. Chapman; and another paper by the same author, "On the Estimation of Nitric Acid in Potable Waters." He first distils the water with pure caustic soda to remove all ready-formed ammonia, and then adds aluminium foil and distils again. The nascent hydrogen reduces the nitric acid to ammonia, which is collected in the receiver and estimated by Nessler's test. A general discussion on Messrs. Wanklyn and Chapman's proposed method of water analysis then took place, in which Dr. Williamson, Dr. Odling, and Professor Abel took part. The general opinion seemed adverse to the process.

Mr. W. H. Perkin, F.R.S., then read a paper "On the Hydride of Aceto-Salicyle," a body which was mentioned in a former paper. It is a white crystalline mass, possessed of aldehydic properties, formed by the action of acetic anhydride on the hydride of sodium-salicyle. A paper then followed "On the Absorption of Vapours by Charcoal," by Mr. Hunter. In these experiments, cocoa-nut charcoal was used, and amongst the substances whose absorptions were ascertained under various circumstances of temperature and pressure were the vapours of ethylamine, iodide of ethyl, acetate of methyl, camphor, nitro-benzol, bisulphide of carbon, alcohol, and methylic alcohol. The next paper was "On the Occurrence of Prismatic Arsenious Acid," by Mr. F. Claudet. This was interesting, as illustrating the dimorphism of arsenious acid. It had been formed by a very slow process of oxidation, and the form was probably modified by the sulphurous atmosphere pervading that part of the mine where it was found. The next papers were two by Dr. Stenhouse, "On the Action of Nitric Acid on Picramic Acid," and "On Chloranil." These were followed by one by Messrs. Chapman and Smith, "On the Action of Zinc Ethyl on Nitrous and Nitric Ethers;" after which the meeting adjourned at an unusually late hour.

At the meeting on March 19th the proceedings were opened by Professor Kolbe, who was invited by the President to give an account of his experiments "On the Conversion of Carbonate of Ammonia into Urea." Professor Kolbe, who spoke in German, explained that he had succeeded in producing urea by heating dry carbonate of ammonia in sealed tubes to a temperature a little lower than that at which the urea formed would be again destroyed. The speaker then referred to the electrolysis of acetic acid, which furnished a new acid isomeric with glycolic acid, but of which the properties were as yet but imperfectly known. Mr. Henry Chance of Birmingham, then delivered a most interesting lecture "On the Manufacture of Glass." The author briefly sketched the history of this manufacture, and quoted several analyses of various kinds of glass. The action of heat in causing dendrification, and of sunlight as affecting the colour, besides other considerations having reference to permanence, were discussed. Mr. Chance appended to his remarks upon glass, a statement of his mode of treating the Rowley Rag basaltic rock of South Staffordshire. This material gives by fusion a black obsidian-like glass, which again devitrified furnishes a material suitable for building purposes and capable of ornamental application. The formation of soluble silicate of soda by Gossage's process was described, and some of the corroded flints exhibited. An excellent series of samples illustrative of the manufacture of glass and of the two materials producible from Rowley Rag, were laid on the table for inspection.

The anniversary meeting of the Society was held March 30th, when the President, Dr. Warren De la Rue, F.R.S., reviewed the progress of the Society during the past year. The obituary notices were unfortunately more numerous than usual. The list of Fellows shows an increase of 11 over those last year, being now 510. Amongst the losses by death may be mentioned Professor Michael Faraday, Dr. C. G. B. Daubeny, Dr. Thomas Clark, Dr. William Herapath, Mr. Robert Warington, Messrs. J. Tennant, Walter Crum, W. H. Gossage, Alfred Noble, William Winsor, and Professor Jules Pelouze. The President indicated some of the leading researches published during the year in the several departments of the science, and referred to the progress made towards establishing the new chemical theory. The investigations of Graham, Hofmann, Kolbe, Abel, Fittig, Frankland and Duppa, Perkin, and Pettenkofer and Voigt were specially mentioned. The discussions on water analysis had elicited facts which would ultimately prove useful in establishing a new method; and the review of geological phenomena from the wide sphere of observation of so eminent a chemist as Mr. Forbes could not fail to be productive of great results. The treasurer's report was very satisfactory, showing that the balance at the bankers of the society was 637*l.*, and the amount invested in Consols 2,347*l.* The election of officers and council was then proceeded with, and after the usual votes of thanks the meeting adjourned.

On Thursday, April 2nd, the first paper read was one by Messrs. Perkin and Duppa, "On the Constitution of Glyoxylic Acid." This was followed by a very long and highly theoretical one by Dr. Odling, "On a Glyoxylic Amide." Mr. W. Chandler Roberts then read a note "On the Occurrence of Organic Appearances in Colloid Silica obtained by Dialysis." The interesting observations which formed the subject of this paper were elucidated by a series of specimens, both of natural and artificial origin, the structures of which were demonstrated by the aid of a microscope and illustrative drawings. In experimenting upon somewhat large quantities of soluble silicic acid prepared in Graham's dialyser, a portion of the liquid product was evaporated slowly in air to compare with the forms of hydrous silica left by a more rapid operation conducted *in vacuo*. All the specimens of jelly dried in air exhibited dendritic forms, varying in size from 0·2 to 0·5 mm.; these were at first supposed to afford indications of the passage of colloid into crystalloid silica, but when magnified 90 linear they appeared as radiating fibres, and upon being further magnified 700 times, each fibre resolved itself into a collection of elongated headed cells, with clusters of circular cells at intervals. Such a structure would indicate a vegetable growth, and the author concludes that the markings, which are similar to those seen in moss agates and Mocha stones, are due to the growth of fungi or mildew in the partially solidified jelly. The spores of organic life were probably derived from the air, since no evidence of similar structure was visible in the specimens of hydrous silica obtained in the desiccator. These last-named productions were very like the opal from Zimapan, but contained 21·4 per cent. of water. Dr. Bence Jones communicated the next paper, in which he demonstrated the "Solubility of Xanthin (Uric Oxide) in Dilute Hydrochloric Acid." This was followed by a continuation of Professor A. H. Church's "Researches on New and Rare Cornish Minerals," in which the author corrected the hitherto-received formula for the mineral *Cornwallite*, showing it to consist of arseniate and hydrate of copper, with a small proportion of phosphate.

At the meeting on the 16th of April, Professor Guthrie described and exhibited an *improved Voltastat*, by means of which the current of a galvanic battery could be maintained perfectly constant and regular by a self-acting arrangement. A paper "On Graphic Formulæ," by the same author, followed, in which he described a new system, founded on the same general principle as that of Dr. W. Crum Brown, but which would, in the words of the author, "serve to illustrate the molecular constitution of compound bodies from a somewhat different perspective." Instead of initial letters the author adopts pictorial symbols by which to represent the elements, and arranges them in a geometrical pattern to construct the compounds formed by their union. In the discussion which followed the reading of this paper, Drs. Atkinson, Russell, Stevenson, and Odling spoke briefly, and, in a general sense, adversely, as to the desirability of introducing the system to the notice of the student. Dr. J. H. Gladstone followed with a paper "On the Tetraphosphoric Amides," compounds produced by the action of water on the amidated oxychlorides of phosphorus; and the proceedings concluded with a paper by Mr. Carter Bell "On the Solubility and Crystallization of Plumbic Chloride in Water, and in Water containing various proportions of Hydrochloric Acid." The author finds the degree of solubility in pure water to be about 1 part in 121 parts, instead of in 135. The solubility in hydrochloric acid decreases up to a certain point, when the curve commences to ascend.

The meeting on May 7th was very fully attended, and many distinguished visitors were present to hear Mr. C. W. Siemens, F.R.S., deliver a lecture "On the Regenerative Gas Furnace as applied to the production of Cast Steel." The following is a very condensed account of this important lecture; and it is to be regretted that the many demands upon our space will not permit of its being given more fully. The lecturer commenced by briefly sketching the properties and modes of preparation of cast steel, which he defined as a compound of iron and carbon possessing the remarkable property of becoming exceedingly hard when heated and suddenly cooled. Steel containing 1·4 per cent of carbon partakes of the character of white cast iron, and below 0·3 per cent. the metal is incapable of being hardened. The presence of manganese improves the quality of steel, apart from its function in removing sulphur and other impurities. Tungsten, in quantities of about two per cent., has the remarkable property of increasing the power which steel possesses of retaining magnetism when hardened. This property of tungsten was illustrated in the lecture-room by a small permanent magnet of horse-shoe form, which supported twenty times its own weight from the armature; the celebrated Haarlem magnet being incapable of lifting a weight more than thirteen times heavier than itself. The principle of Mr. Siemens's plan of heating is already well known. The fuel is heated upon an inclined fire-grate, where it undergoes a kind of slow combustion which results in the formation of carbonic oxide; this inflammable gas is then conducted from the "producer" to the hearth or working platform of the furnace, where it meets a current of air already raised to a high temperature, which enables it to burn with great intensity; and the excess of thermal power, instead of being allowed to pass direct into the chimney and thus become wasted, is forced to traverse an intricate structure of brick-work, which absorbs so much heat that the escaping gaseous products of combustion rarely indicate a temperature above 300° F. At a suitable stage of the operation the gas-valves are reversed, and both carbonic oxide gas and air are forced to traverse these heated brick chambers in a contrary direction, so that they may in turn become the recipients of that heat which in ordinary constructions of furnaces would have been lost. The ashes and clinkers are in this way entirely separated from the region of manipulation, and are removed from the grate at intervals of one or two days. The author estimates the temperature produced by the combustion of the gas and air to be 1,000° to 1,300° F. when they are cold to begin with; but when they have been separately passed through the regenerator and thereby raised to a temperature of, say, 1,000° F. beforehand, the temperature of their combustion will be, say, 2,000°. The surplus heat from this will then raise the temperature of the regenerator still higher, and the gas and air will consequently attain a higher degree of heat before they unite. The platform of heat, so to speak, on which they commence their combustion, will be raised each time, until practically there is no limit to the degree of temperature which may be attained in this manner—the whole mass of the furnace, with its contents, having occasionally been melted down into one mass. The special furnace which Mr. Siemens has erected at Birmingham for the direct production of steel from the ore, has a tunnel-head or cylindrical hopper, fed with iron ore and small coke, passing through and raised above the crown of the regenerative gas furnace; the lower part of this upright cylinder rests in a bath of molten pig-iron, which dissolves the reduced (spongy) iron as quickly as it is separated from the ore. A blast-pipe descends through the stack of ore, and the process is interrupted when the steel is ready for casting, after which the charge of pig must be renewed. It is a very important point in connection with these furnaces, that the atmosphere of them may be changed at will into an oxidizing, reducing, or perfectly neutral condition, merely by altering the proportions of air and gas. After the delivery of this lecture, which was amply illustrated with experiments, specimens, and a series of diagrams and dissected models, an animated discussion followed, in which the President, Mr. Cowper, Professor Abel, Dr. Miller, Dr. B. H. Paul, Dr. Williamson, and Dr. Odling took part.

On May 21st, Dr. Russell opened the proceedings by showing some experiments "On the Application of the Measurement of Gases to Quantitative Analysis." The author considers the system of measuring to be more accurate than weighing in a variety of analytical operations wherein gases are evolved, and the results which he has obtained certainly corroborate this view. In the discussion which followed, Dr. Williamson said that as a rule the process of measuring was more accurate than weighing; for, whilst we could not weigh closer than one-tenth of a milligramme, it was possible to measure volumes of gas within one-hundredth part of a cubic centimetre. Mr. W. H. Perkin then read a paper "On the Combining Powers of Carbon." This was very long and theoretical, and related to the inquiry whether all four affinities or combining units of carbon are of equal value.

The proceedings were brought to a conclusion by a short paper by Mr. Parnell "On the Reducing Action of Peroxide of Hydrogen and Carbolic Acid."

6. ENGINEERING—CIVIL AND MECHANICAL.

The gradual, though, it is to be hoped, certain return of confidence in various existing undertakings, recently shown by the state of the money market and the quotations of shares, cannot fail to have exercised a beneficial influence on the progress of engineering schemes; but it must be acknowledged that there is still room for much improvement.

Ship-building.—The state of trade in the northern parts has of late exhibited a decided improvement, but the same cannot altogether be said of ship-building on the Thames. Messrs. Napier and Sons of Glasgow have recently completed an armour-clad twin-screw turret-ram for the Dutch, and Messrs. Laird of Birkenhead, have launched two sister monitors for the same Government. The last-named firm are also building a turret-ship of 4,200 tons, and a broadside-ship of the 'Invincible' class for Her Majesty's Government, as well as a composite gunboat for service in the China seas. A gunboat on a new model has recently been built for the Admiralty, on the Tyne, from the designs of Mr. G. Rendel, of the firm of Sir W. Armstrong and Co.; this vessel is only 70 feet long by 25 feet beam, having twin screws driven by two pairs of condensing engines. She carries as heavy a rifled gun as any in the Navy, mounted in the fore part of the vessel in a line with the keel, and firing through a bulwark, or screen, over the bow, which is cut down and plated something like that of a monitor. On the Thames the 'Repulse,' to carry eight guns, and of 800 horse-power, was launched at Woolwich Dockyard on the 25th April; and at Chatham, in addition to the 'Sultan,' a powerful new iron-clad ship, of the 'Hercules' class, has recently been laid down. There is now, it appears, no doubt about the closing of the minor Government ship-building yards, an order having been received for Deptford to shut up in the course of the year, and it is thought that Woolwich will, in all probability, follow Deptford.

On 25th April last, the first gunboat ever built in Ireland was launched from the yard of Messrs. Harland and Wolff of Belfast, which is one of six gunboats being built for the British Government.

Docks and Harbours.—One of the greatest and most important recent additions to private dock accommodation on the Thames was made on 14th March, by the opening of the Millwall Dock basins and warehouses; and on 21st April the foundation stone was laid of the first of four large new Graving Docks to be constructed at Chatham.

A new harbour under construction at Torquay, at the cost of Sir L. Palk, M.P., is rapidly progressing; it is intended to extend the harbour some 600 feet, and vessels drawing a much greater depth of water than heretofore will be enabled to enter it. A considerable sum is also about to be expended on the improvement of Great Yarmouth Harbour.

Works for the improvement of the basin at Brest were commenced so far back as 1863, but after sixteen months of persevering efforts, the contractor failed to make a water-tight dam. Recourse was then had to the compressed air process, and a caisson was sunk, having a capacity of 2,427 cubic metres, in which forty men have been working day and night in four-hour shifts.

During the recent visit of the Duke of Edinburgh to Australia, his Royal Highness laid the foundation stone of a fine Graving Dock at Williamstown, Victoria.

River Improvements.—The works undertaken for the improvement of the Sulina mouth of the Danube appear to have been successful, the depth of the channel having been increased to an average of 15 to 16 feet, while the Sulina Pass, formerly regarded as one of the dangers which shipping had to encounter, has now become one of the best refuges on the coast of the Black Sea.

Water Supply.—The Carnarvon Waterworks were opened by His Royal Highness the Prince of Wales on 25th April last. They are supplied with water from Llyn Quellyn, a lake situated about six miles from Carnarvon, and 600 feet above the level of the town.

The new waterworks at Helensburgh were opened on 26th March last. The water is collected from two streams intersecting the Mainshill lands before they reach the mossy portion of them adjoining the upper, or compensation, reservoir; the lower, or storing reservoir is seven acres in extent, and has a storeage capacity equal to a supply of 25 gallons to each inhabitant for a period of five months.

An extensive system of works for the supply of Calcutta with water are now in course of construction. The supply is drawn from the Hooghly at a point about sixteen miles north of Calcutta, and after being purified is carried by three branches to the

Southern, North-eastern, and North-western districts of the city respectively.

Railways.—The new line, belonging to the London and North-western Railway Company, from Llanrwst to Bettws-y-Coed, has commenced to carry passengers. The new line between Edinburgh and Leith was gone over on the 14th May, and was expected to be opened in about a week from that time.

The break of continuity which the Girdle of Paris Railway still presents, between the Batignolles-Clichy goods station and the Courcelles station on the Anteuil line, will soon disappear; the earthworks of the section in question being now nearly completed. The Paris, Lyons, and Mediterranean Railway Company appears to be pushing forward its lines in Algeria with much energy; that from Algiers to Oran is now in progress throughout, and one section—from Relizane to Oran—is expected to be opened for traffic in July. A second line, from Phillippeville to Constantine, is to be completed for traffic in the course of 1869.

Upwards of 472 kilomètres of railway are expected to be completed in Italy during 1868. Of these, the Lecce and Zellino line was opened at the commencement of February, and its extension to Otranto has been definitively approved. Mr. Fell's summit-railway over Mont Cenis has certainly not hitherto fulfilled the expectations of its promoters. In May last the Duke of Sutherland went over the line between St. Michel and Susa, a distance of 48 miles, in 4 hours 6 minutes, after deducting the time in stoppages for inspection. The line was opened to the public on 15th June.

The concession of a Government guarantee has been given to the Indian Branch Railway Company for its lines in Oudh and Rohilcund, and the extension of the Oudh system is now being proceeded with. The whole distance between Sholapoor and Raichore, on the Madras Extension line, is in course of completion, the rails having now been laid for about fifty miles beyond Sholapoor.

On 18th April last the rails of the United Pacific Railroad were laid on the Rocky Mountain summit of the line; according to Bilnkerderfer's survey, the railroad crosses the mountains at this point at an elevation of 8,242 feet, being the highest point reached by any railroad in the world.

Bridges.—The North-eastern Railway Company have set resolutely about the replacement of the whole of their numerous wooden viaducts with stone and iron, and in some places with solid embankments. The Hutton, Malton, and Whitby viaducts have been completed, the Ripon is in progress, and the Norton is being filled up.

A bridge was recently constructed by the Louisville and Nashville Railroad Company over the Cumberland river, at Nashville, which comprises two spans of 205 feet each in the clear, and a swing-bridge, giving two openings, and measuring over 276 feet. A new suspension-bridge has also been constructed over the same river, in Tennessee, connecting Nashville and Edgefield, to replace the one destroyed by the Confederate General Floyd when in possession of Fort Doneldson. A bridge is now in course of construction over the river Ohio, at Louisville, which is the longest iron bridge yet attempted in the United States. It will, when completed, carry across the Ohio a line connecting the Louisville and Nashville with the Jeffersonville and Indianopolis railroad, and form a connecting link between two immense railway systems—the northern and the southern, at present divided by the Ohio river. The Boston and Providence Railway Company are constructing a bridge from India Point over the Seekonk river, on a plan which embraces some new features. The whole length of the bridge is 876 feet, and the supports in the river are iron cylinders filled with wooden piles and concrete. The building of an iron bridge over the Great Miami, on the Ohio and Mississippi Railway, is considered a rapid feat in railway engineering. The first train crossed on the 15th December last, just 120 days from the time the first pile was driven, and 9 days and 4 hours from the time the last stone was put in place.

Tunnels.—On the 1st of last November, the heading of the Hoosac tunnel had reached a total of 4,382 feet from the east opening, and 1,004 feet in the western shaft. On the whole, confidence is expressed in the future rapid progress of this work.

Telegraph.—The English telegraphic system is soon to be connected with that of Denmark, Sweden, and Norway, by a cable now in course of construction, and which is to be laid under the North Sea. On 1st April, the Chancellor of the Exchequer brought in a Bill for giving to the Postmaster-General power to buy up, and work telegraph lines in this country in connection with the Post-Office.

The Indo-European Telegraph Company, for working a line of telegraph through Prussia, Russia, and Persia, has recently been successfully started; and the Anglo-Mediterranean Telegraph Company, which proposes to effect an independent communication between England and India by deep-sea cables through the Mediterranean and Red Seas and the Persian Gulf, has also been established, so there is now a prospect that before long England will possess two separate lines for telegraphic communication with India entirely under English supervision and control.

Mechanical.—A very clever steam flying-machine has recently been invented by Mr. Joseph M. Kaufmann of Glasgow, the action of which resembles that of the wings of a bird as closely as possible. It will appear at the Exhibition of the Aeronautical Society at the Crystal Palace in June.

We must not omit to notice the Steam Stearing-gear, fitted by Messrs. George Forrester & Co., of Liverpool, to the Great Eastern steamship, from the designs of Mr. J. McFarlane Gray. This apparently complex, though really simple machine, according to the evidence of Sir James Anderson, "saved the labour of eight men, and acted upon the rudder with a facility and certainty that no mechanical labour could effect." The construction of a thoroughly effective steam stearing-gear is no easy matter, for whilst the rudder should be under perfect command, it should at the same time be able to yield if exposed to excessive strain by the action of the waves. It would be impossible here clearly to describe this machine without the aid of drawings, but it may suffice to state that the above desideratum is fully accomplished by it; the rudder being capable of yielding, and at the same time returning to the desired position when the disturbing force is removed.

A very clever portable drilling-machine has recently been introduced by Messrs. Westray and Forster of Barrow-in-Furness, which has been designed so as to enable the drill to be worked at any angle, and to be used to drill holes anywhere within range of the machine when fixed.

A new arrangement of boring-machine has recently been designed and patented by Mr. Thomas Greenwood of Leeds, which is specially intended for boring gun-barrels, shafting, or other articles in which a deep hole is required to be formed. The work to be bored is mounted above a tank containing lubricating material, and in this tank the drills are placed, the work being bored upwards from the lower end.

Golay's millstone cutting and dressing machine has recently attracted great attention, and large sums have been paid for the right to manufacture it in this country. With this machine, the "cracks" are cut by a diamond fixed on the edge of a small disc, revolving at a very high speed, its spindle being mounted on a carriage which can be moved to and fro on the line of the cracks.

Experiments have recently been made at Chatham, with very satisfactory results, to test the merits of a new application of the diving apparatus invented by Mr. Siebe, submarine engineer, by which two divers can be sent down in any depth of water, and be supplied with air from the same pump. The diving apparatus is fitted with a self-acting pressure gauge, and the invention can be used as a submarine lamp.

A new method of extinguishing fires by the application of carbonic acid gas, projected from a portable fire-engine, was lately tested upon the battery in New York city. The engine is about the size of a common garden engine, it is worked much in the same manner, and may be operated by two men. When in action two cylinders are employed to supply an air-chamber, the pressure from which, acting upon the carbonic acid gas formed by the mixture of solutions of tartaric acid and carbonate of soda, or other suitable materials, forces it through a hose, by means of which it may be directed wherever required.

7. GEOGRAPHY.

(Including the Proceedings of the Royal Geographical Society.)

The attention of the Royal Geographical Society, so far as it is not concentrated upon individual interests or the exciting game of politics, is directed to the little band of men who, in their indomitable perseverance, their cautious advance, their submission to scientific arrangement, the purpose and success of their expedition, and even their ethnological heterogeneity, represent, with tolerable fidelity, the relation of the British empire to outer barbarians. Neither the smallness of the force sent to Abyssinia nor the contemptible character of our opponent, is a gauge of the interest felt by educated men in the success of the expedition; because it has been all along seen that the contest was rather against nature than against man, and that the prize to be won was mental and moral rather than physical and political. That an engineer officer should be in command and that a select body of scientific men should accompany the force, was as essential to its character as that our Indian troops should make the roads, that "twenty men of the line, two artillerymen, an officer, and *the Press*," should capture and turn thirty guns, or that a newspaper correspondent should criticize the "brilliant blunder" of a commander. The real and permanent advantage that we shall gain from the expedition depends to a greater extent upon the care and the circumspection of the representatives of science, who, for the first time, accompany an invading army, than upon the valour, the foresight, and the good fortune of our troops.

Lieutenants Carter, Holdich, and Dumler, of the Royal Engineers, have been busy with a trigonometrical survey of the route of the army and of the country, from ten to fifteen miles on each side of it, including all the principal peaks visible along the road. This will furnish accurate data, to which may be hereafter safely added less carefully determined information.

In the meantime, Mr. Clements R. Markham is obtaining historical and topographical detail of the lines of watershed, geological structure, zoological and botanical products, all of which will no doubt be given to the public in papers before the Royal Geographical Society and in periodical publications. Several other members of the expedition have also used their spare time in making zoological and botanical researches, whilst the excellent sketches that have from time to time appeared in our illustrated newspapers have made all the world acquainted with the peculiar characteristics of various kinds of scenery in Abyssinia, which for grandeur and picturesqueness could scarcely be equalled.

A lecture on Abyssinia was lately delivered by Sir Samuel Baker at the Royal Institution, which, except that it contained a fair description of the surface of the country, added but little to the information already possessed or within the reach of every one of the enormous audience assembled to greet the traveller. By reproducing stories of Moses and of the Queen of Sheba entirely depending on tradition, and by the application of the indefinite word "Ethiopia" to Abyssinia wherever it may occur in biblical history, Sir Samuel showed that his authority as a historical critic could scarcely be so great as when he confined himself to his proper subject of geography.

These doings in the more northerly portion of the enormous district drained by the Nile (for near Adigerat and Antalo the British troops came upon the head waters of certain tributaries of the river of Egypt) have caused the interest about the explorers of the southern tributaries of the same stream to flag. A fictitious excitement concerning the researches of Dr. Livingstone was for some time kept up in consequence of the credit given to the untrustworthy story of the Johanna men, even to the extent of publishing a biography of the scientific missionary in the obituary of the 'Année Scientifique,' although Sir Roderick I. Murchison all along showed the improbability of their account, and the unreliable character of the men was patent to all who read their testimony. It is satisfactory to know that the authors of the false account are likely to reap the reward of their villany from their own sovereign, the Sultan of Johanna. The letters lately received from Dr. Livingstone, of which we give an abstract below, have been read, however, with great enthusiasm, though they serve rather to stimulate curiosity than to give much information concerning the countries he has traversed. It is extremely difficult in the present state of our knowledge to follow the statements of the Doctor, who does not seem to have got over the fault which so greatly spoilt the effect of his first work—a muddled and confused style. It is still uncertain by which route the traveller may return, but if he retraces his steps, he will probably fall in with a party of Irish officers who intend to take a small iron boat, fitted with a steam screw, up the Zambesi and the Shire, and then across to the lake Nyassa, which last piece of water they purpose surveying thoroughly, especially on its little-known northern boundary. It is to be hoped that the nationality of Captain Faulkner and his companions will not lead them to too hasty conclusions,—and that the results of their expedition may be worthy of the excitement caused in Dublin by an Irish attempt at solving the problems before them. The Zambesi itself is in a fair way to be known as well as the Rhine, as it not only forms the highway by which book-writing travellers journey towards the great lakes of southern Africa, but that wayfarers like Mr. Chapman, who attempt to cross the continent from west to east, make use of this opening. Another new source of attraction to this river is the discovery of a gold-field at a short distance from its northern bank, by M. Manch, who has also found another gold-field somewhat to the south-west of the former, nearer the colony of Natal. On the Guinea coast Mr. Winwoode Reade, who has already penetrated to the gorilla country, is commencing an exploration under the auspices of the Royal Geographical Society, by advancing up the Assinie river. The physical condition of the valley of the Nile in Egypt and Nubia, especially in its relationship to the intellectual precocity of the former country, receives considerable light from the careful survey of M. Ampère.

The course of geographical interest follows in the track that history has previously travelled. The earliest civilized continent, Africa, is now the least known and the most provocative of discovery. Asia, which followed closely on the path pioneered by Egypt, next affords the widest field for exploration and research The examination of the foundations of Jerusalem (one of the earliest of the old centres of civilization), interesting from so many points of view, has been delayed, though not entirely stopped, by the jealousy of the Turkish authorities. It is to be hoped that the difficulties, whatever they may be, will be overcome before the cooler weather again gives an opportunity of recommencing the labours of tracing water-courses, following drains, and laying bare foundations. Since Mr. Layard's investigation of the cities of northern Mesopotamia, we have heard but little of the remains of the old Assyrian and Persian empires. The necessity for collecting animals for the transport corps in Abyssinia has given some of our young officers the opportunity of traversing Persia. One of these gives a description of Persepolis as still containing much that is worthy of investigation, and it is to be hoped that this and other similar places will be examined by those who, enlightened by the discussions on ancient architecture and manufactures, have had their interest awakened to the seats of ancient learning and art.

The advance of the Russians and of Russian influence in Central Asia is still the cry of those who think our Indian empire is not safe unless it is enlarging its boundaries, and this cry is from time to time awaked by reports of fresh victories of the Muscovites. A knowledge of the condition of the countries to the north of the Himalayas may be scientifically useful; but meddling with the politics of this region may be anything but advantageous to our already overgrown empire, however much it may be desired by the continental enemies of Russia and a certain school of Indian statesmen. The condition of the vast empire of China, which seems to be so rapidly changing its character, is of much greater importance to the British merchant. Instead of crowding their over-peopled land and rivers, the Chinese are now constantly passing backwards and forwards to and from the various gold fields of America and Australia, where their incursions have a very serious effect upon the labour-market, and their habits incite a considerably amount of enmity. If, as seems probable, this huge kingdom should fall to pieces from its own inherent want of cohesion, it may become a matter of importance to us who succeeds to the various portions of the ruins of the mighty fabric. The neighbouring and closely allied kingdom of Japan is in like manner undergoing convulsions, both social and political, about the nature of which it is difficult to judge. The old aversion to foreigners and to intercourse with other nations seems to have left the middle and lower classes of the nation, who are making their influence felt by the governing class, and the presence of a troop of jugglers or tumblers among us has a deeper significance than might at first sight appear. It is a more trustworthy earnest of future intercourse than the appearance of their ambassadors at our international shows, or even treaties with rulers who cannot divert popular feeling. The internal evidence of the same change is to be seen in revolutions and in the attack upon our ambassador so satisfactorily punished by the Mikado, whom he now visits in place of the Tycoon who received our former attentions.

Two expeditions into Central Australia are spoken of. The one by Captain Cadell is nearly completed, after having traversed the country from the northern boundary of Southern Australia to the northern coast of the continent. Three rivers and a large harbour have been discovered. The other is the proposal of Dr. Neumayer, director of the Observatory at Melbourne, who is anxious to carry his line from east to west, from Port Denison to Swan River. Dr. Neumayer is anxious to have more attention paid to science in the new exploration than has been the case before; and in his opinion the expense ought to be defrayed partly by the colonies and partly by the mother-country.

The country, so long marked on maps as Russian America, but which on its acquisition by the Government of the United States required a new name, has been called from its principal peninsula Aliaska or Alaska. In Yankee parlance it is sometimes Walrussia. But little is known of this region, which is said to be of no great value on any account, and was only bought by the Americans through jealousy of British influence on their continent. An artist, Mr. Frederick Whymper, who spent a considerable time in that region, has traversed a large portion of the course of its principal river, the Yukon or Kwichpak, and has at length returned to England with the results of his stay, and we may expect shortly to hear something of his discoveries. He describes the climate as extreme, and the inhabitants vary in character from the Eskimo to the Red Indians. A series of sketches and a collection of characteristic articles made by the natives were exhibited by Mr. Whymper at the evening reception given by the President of the Royal

Geographical Society. The Red Indians are, like so many unfortunate natives of other lands, being driven out by our colonies of Vancouver Island and Columbia from their old hunting grounds through the forcible purchase of their land, which the Indians would willingly keep if they were allowed. It is the old story, the European makes use of the power that civilization gives him to act as an uncivilized savage would be ashamed to act, and then it is said that no barbarous nation can exist where educated man touches upon his borders. One rather awkward-looking fact accompanies the advance of the European. The price of wives increases as one nears the white settlements, and a regular slave trade is known to exist. A strong desire has been exhibited by the colony of British Columbia to be admitted into the confederacy with Canada and the other settlements of British America, provided only that a means of communication with these latter colonies be made from Lake Superior over the Rocky Mountains. The other parties to the confederacy seem willing to meet their wishes, and it is to be hoped that a strong alliance may be found to resist any attempts to alienate or seduce any of these our dependencies, or to sow discord where unity is so essential. The new territories of the United States are each in their turn explored by Government officials, and the various productions, mineral and vegetable, are described and catalogued. Nebraska has in this way been rendered accessible, and expeditions are still in progress in Colorado and Dakotah. Lignite has been found over a large extent of country in the former territory, and iron ore is in abundance in the same neighbourhood. Unlike the adjoining British colony, the Americans of California are not content with a mere road, but have already made lines of railway where no European would dream of laying a tramway, but one of the most extraordinary of these undertakings, and a very successful one too, is the Central Pacific Railway, which commencing in California passes the Sierra Nevada through a tunnel, and is descending into the plain of the great Salt Lake city to Utah. The rails are being laid at the rate of a mile a day. When this is finished there will be no more occasion for those trying journeys across the prairies so well described in Hepworth Dixon's 'New America,' nor for the scarcely less unpleasant journey round by Central America. But little seems to be known about this latter country, to judge from a late correspondence in which it is contended by one of the opposing parties that there is a water communication between the Lakes Managua and Nicaragua, whilst the other denies this. The explanation seems to be that some years ago the dry seasons lowered the former lake to such an extent that there was no overflow of water along the channel which has since been navigated by one of the correspondents. The Panama railroad, however, has its historian and guide, Dr. F. N. Otis, and around books of the character which he has written, there is soon accumulated an amount of fact which, without some nucleus of crystalization, is apt to flow away in a state of solution.

The German expedition to the North Pole has started from Bergen, and Professor A. E. Nordenskiöld has announced to the Royal Society that the Swedish Government has granted a steamer, provisioned for one year for the purpose of Arctic exploration, and that some private gentlemen have contributed towards fitting out the expedition.

Earthquakes are recorded in the Sandwich Islands (near the volcano, Mauna Loa, which was in violent eruption) at Tachkent (?) and about Vesuvius. The latter mountain is being watched not only by Palmieri and several Italian *savans*, but also by Professor Phillips of Oxford. Very valuable records of the lengthy disturbances will have been made by these and other scientific observers of the changes that have taken place, and it is to be hoped that the theory of volcanoes will receive some enlightenment.

We have to regret the death of Mr. John Crawfurd, whose face must be well known to all frequenters of our learned societies. His fame was won originally in the Malay peninsula, of which he wrote a history as well as a dictionary and grammar of the language, but he did not confine himself to matters connected only with that part of the world, but on most subjects, geographical and ethnological, he held, and frequently expressed, opinions of his own. He died at an advanced age in a sudden and peaceful manner.

PROCEEDINGS OF THE ROYAL GEOGRAPHICAL SOCIETY.

The safety of Dr. Livingstone having been doubted by some members of the Society in spite of the opinion constantly expressed by Sir R. Murchison, letters from that traveller which were read at the tenth meeting excited some considerable interest. The news in these, however, did not reach to a very late period, the doctor's own letter being dated Bemba (lat. 10° 10′ S.), 2nd February, 1867, whilst that from Dr. Kirk contains news of him up to October last. The traveller, who had with him only the African boys educated at Nassick, Bombay, had remained at the town of Mataka, a chief whose dominions stretched from the watershed between Lake Nyassa and the sea to the lake itself, a distance of fifty miles. Hence the journey seems to have been continued westwards, but whether round or across the lake does not appear. The next points made seem to have been some of the tributaries on the left bank of the Zambesi, *viz.* the Chambese and the Loangwa, the watershed between which streams the doctor thought he had gained at Bemba. At the time he wrote he was making for Casembes, and thence he was to go to the lake of Taganyika, which Dr. Kirk says he reached in October last at Ujiji, at the point where stores awaited him. These letters were sent down by Arabs travelling to Ragamoyo, a place on the coast near Zanzibar. Letters, maps, and stores would meet the doctor at Ujiji, being forwarded from Zanzibar.

The Rev. F. W. Holland, during the last winter, has made a third visit to the Sinaitic peninsula. The results of his journey were given in a paper read on the 11th May. Starting from Suez on foot, he reached the monastery at the foot of the Jebel Musa (Mount Sinai), his head-quarters, whilst he explored the whole country in that neighbourhood for four months. Letting himself down from the wall of the convent, he daily traversed some mountain path, assisted by Arabic ibex hunters. Occasionally he took an Arab to carry his blanket and bag of provisions when he intended to camp out for three or four nights. He was thus enabled to take heights of mountains, and to measure and map out valleys hitherto incorrectly given. He found more vegetation than previous information had led him to suppose, and two or three springs were to be discovered on every mountain. Jebel Um Alowee (possibly a corruption of Elohim), north-east of Jebel Musa, is a fresh discovery of Mr. Holland's, and he puts it forward as a possible rival to the latter mountain as the true Sinai. The wilderness of Sin he would identify with the plains of Es Seyh ; and he adds his protest to that of many others against the theory that the Sinaitic inscriptions are to be esteemed the work of the Israelites on their journey out of Egypt. The next paper was by Commissioner Chimmo on the north-east coast of Labrador.

At the anniversary meeting, on Monday, 25th of May, the Founder's Medal was awarded to Dr. Augustus Petermann, the well-known geographical writer, the originator of the German expedition to the North Pole, the editor of the 'Geographische Mittheilungen ;' and at the same time the Patron's or Queen's Medal was assigned to M. Gerhard Rholfs, on account of his journeys into the interior of Africa from the northern coast, from which, on one occasion, he penetrated as far as the Guinea coast. A gold watch also was awarded as an extra distinction to the pundit, whose name has not yet appeared, but who was employed by Captain Montgomery to survey in Thibet. The report of the Council, recommending the presentation of two gold and two bronze medals to the successful candidates at an annual examination in physical and political geography, was afterwards received and approved. The Chief Commissioner of Crown Lands has promised the Society a site for building facing the Thames Embankment, where the maps and books of reference of the Society might be readily accessible to the public.

The President, in his address, enumerated those works that had been added to this library during the last year, amongst which may be mentioned Keith Johnson's New Atlases, and Major's 'Life of Prince Henry.' The obituary of the year included the names of the late President, Mr. William John Hamilton, Lord Rosse, Lord Colchester, the Right Hon. Sir George Clark, Captain James Mangles, R.N., Mr. Ashurst Majendie, the Rev. Pierce Butler, Sir Charles Lemon, &c., and as we have mentioned before, Mr. John Crawfurd. After a brief sketch of the additions to our geographical knowledge, as they have from time to time appeared in these Chronicles, Sir R. Murchison dwelt at some length upon the progress of Dr. Livingstone, and the success of the expedition sent in search of him. He then pointed out the three routes which were open to the traveller on his return, showing that, according to his own calculation Dr. Livingstone might return to England by August next, whereas according to Sir Samuel Baker he possibly might arrive at Gondokoro next April, but not before, and he scarcely could with probability be expected until a much later date. The President referred to the appointment by the Government of Mr. Clements Markham, as geographer to the Abyssinian expedition. One positive gain to the Society, resulting from this appointment, was the desire of Sir Robert Napier to become a member of that body. The memoirs of Mr. Markham might be looked forward to as one of the most worthy parts of the Journal of the Society.

8. GEOLOGY AND PALÆONTOLOGY.

(Including the Proceedings of the Geological Society.)

"The unique specimen of *Archæopteryx lithographica* (von Meyer) which at present adorns the collection of fossils in the British Museum, is undoubtedly one of the most interesting relics of the extinct fauna of long-past ages; and the correct interpretation of the fossil is of proportional importance." With these words, Professor Huxley commences a paper, read before the Royal Society on January 30th, the object of which is to show that Professor Owen has mistaken the dorsal face of most of the bones for the ventral; the left femur, left tibia, and bones of the left foot for the "right femur, tibia, and bones of the foot," and so forth. Professor Huxley concedes that the furculum (if it be such) turns its ventral surface to the eye, and he suggests "that it is the *bouleversement* of this bone which has led to that reversal of the proper nomenclature of the other bones, which, could it be sustained, would leave *Archæopteryx* without a parallel in the vertebrate sub-kingdom." By the light of his correction, however, he considers that many points of the structure of this remarkable fossil "acquire an intelligibility which they lose to those who accept the interpretations given in the memoir" by Professor Owen. But the "furculum" still presents an osteological difficulty which even Professor Huxley cannot surmount. He is also of opinion that if the head of Archæopteryx, when discovered, should possess jaws containing teeth, it would not, to his mind, on that account, cease to be a bird, any more "than turtles cease to be reptiles because they have beaks." An abstract of this important paper will be found in No. 98 of the 'Proceedings of the Royal Society.'

Another of Professor Owen's papers has been severely criticized by Messrs. Albany Hancock and Thomas Atthey. On June 3rd of last year Professor Owen read a paper "On the Dental Characters of Genera and Species, chiefly of Fishes, from the Low Main Seam and Shales of Coal, Northumberland," before the Odontological Society of Great Britain. An abstract of this paper appeared in the next (July) number of the 'Geological Magazine,' and the following number of that periodical contained a criticism upon it from the pen of Mr. Thomas Atthey. The paper having been published in full, with illustrative plates, in the 'Transactions of the Odontological Society' for 1867, Mr. Atthey, now in conjunction with Mr. Hancock (a well-known naturalist, and one of considerable eminence as a malacozoologist), has published his criticisms in detail in the April and May numbers of the 'Annals and Magazine of Natural History.' Professor Owen describes twelve genera of Fishes and Batrachians; but Messrs. Hancock and Atthey find themselves "compelled to conclude that there is positively not a single novelty in the whole series." For instance, they state that "it is apparently on fragments of the jaw-bones and on the teeth of *Rhizodopsis sauroides* that Professor Owen has founded the *Dittodus parallelus*, *Ganolodus Craggesii*, *Characodus confertus*, and the Batrachian genus *Gastrodus!!*" Again, other remains, described as teeth of a small fish by the name of *Mitrodus quadicornis*, his opponents consider to be a large kind of dermal tubercles, and remark, "this 'minnow,' then, of our shales is found to be identical with *Gyracanthus tuberculatus*, perhaps the largest fish of the Coal-measures." To the younger palæontologists these confident assertions of Professor Owen's errors will appear incredible. It therefore seems highly desirable that the matter should be investigated by yet one more eminent odontologist.

The fossils of the Portlandian deposits of the department of the Yonne have been carefully described and figured by M. de Loriol, in a monograph by that palæontologist, and M. Cotteau.* The latter author divides the series into two zones, namely, a lower one characterized by *Ammonites gigas*, and an upper by *Pinna supra-*

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* Bull. Soc. d. Sciences hist. et nat. de l'Yonne, 2^e^ série. Vol. i., 1868.

jurensis. The richness of the upper zone contrasts very strongly with the poverty of the lower, the species yielded by the whole formation numbering 122, of which only thirteen belong to the zone of *Ammonites gigas,* four of them being common to both. Twenty-six species are common to these beds and the lower zones of the "terrain Kimméridien," and twenty-two occur in the Lower Portlandian of the Boulonnais, while only four are common to them and the Upper and Middle Portlandian. To the Lower Portlandian, therefore, the authors refer the two zones of the Yonne formation. M. Cotteau, who has contributed the geological portion of this excellent monograph, records that the Neocomian beds are found reposing sometimes on the zone of *Ammonites gigas,* and sometimes on that of *Pinna suprajurensis.* From this fact he infers the existence of a stratigraphical break or unconformity between the two formations. M. de Loriol, however, from a palæontological standpoint, regards these two zones as two *facies* of the Portlandian, inferring that in the west of the Yonne district circumstances favoured the deposition of the zone of *Pinna suprajurensis,* or, in other words, the existence of its rich fauna, while in the remainder the more scanty population of the zone of *Ammonites gigas* could alone flourish. Similarly with the Neocomian, which at Bernouil is represented by the remarkable zone of *Peltastes stellulatus,* covering the Portlandian beds in that area, while at Auxerre the latter are succeeded by the ordinary marls and yellow limestones of the Lower Neocomian formation. M. de Loriol also remarks that the division between the Cretaceous and Jurassic series appears to be less decided in the Alpine area than in any other.

In a paper on the classification of certain Fossil Corals, published in the recently issued volume of the 'Philosophical Transactions' for last year, Dr. Duncan comes to the conclusion that the genus *Palæocyclus* must be abolished, and that its species must be added to the genus *Cyathophyllum.* Thus a representative of the Tertiary coral-fauna is removed from the Palæozoic. The author also shows that the genus *Battersbya* does not belong to the *Milleporidæ,* but should be associated with the formerly solitary genus *Heterophyllia* in a division of the *Astræidæ.* Thus two genera with Mesozoic affinities are introduced into the Palæozoic coral-fauna.

On March 12th Mr. J. A. Phillips read a paper before the Royal Society on the "Chemical Geology of the Gold-fields of California."* He infers that quartz-veins have generally been produced by the slow deposition of silica from aqueous solutions, that their formation is due to hydrothermal agencies, and that the silica may have been slowly deposited at low temperatures. The author also speculates on the cause of the presence of gold in the same solution, and suggests that the bisulphide of iron may have been connected with the solvent by which the precious metal was held in solution.

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* 'Proceedings of the Royal Society,' vol. xvi., No. 100, p. 294.

In a short paper in the 'Bulletin' of the Geological Society of France,* M. Gaudry announces that his researches at Pikermi have led him to doubt in some cases the generally received proposition, that if in a deposit we find the remains of vertebrata † which have not been derived from an older bed, the animals to which they belonged lived at the time that deposit was being accumulated, and that consequently they serve to characterize its age.

The 'American Journal of Science and Arts' for March contains two papers on recent geological changes in China and Japan, namely, one by Mr. Albert S. Bickmore, and one by Mr. Raphael Pumpelly. Both authors describe the gradual rise of the land in eastern China, and give more or less precise descriptions of the extraordinary changes that have recently taken place in the courses of some of the rivers, notably the Yellow River. Mr. Bickmore, however, believes that at Foochow and about the mouth of the river Min, there is an area which has for some time been slowly subsiding, presenting a remarkable exception to the general rule.

In the same number of that Journal is a paper by Mr. E. Andrews, on the Localities of Human Antiquities at Abbeville, Amiens, and Villeneuve, in which he advocates the theory that the annual rainfall at the period when the gravel was being deposited was immensely greater than it is at present; and that the time required for the deposition of the gravel was proportionately short, in consequence of the rapidity of the accumulation. It will be seen presently that Mr. Tylor has, in the 'Quarterly Journal of the Geological Society,' advocated the theory of a Pluvial Period at the epoch treated of by Mr. Andrews.

Professor G. Seguenza has a note in the 'Atti della Società Italiani di Scienzi Naturali' ‡ on the Middle Cretaceous deposits of central Italy, in which he shows their complete correspondence with the Cretaceous rocks of Algeria belonging to the zone of *Ammonites Rothomagensis.* The geological conditions are stated to be precisely similar; and in a list of forty-four species of Italian fossils, forty-three are indicated as occurring also in the African formation. Professor Seguenza, therefore, seems perfectly justified in concluding that the Middle Cretaceous sea extended from Central Italy to the Province of Constantine.

The 'Geological Magazine' for the quarter has been characterized by many valuable papers. The contents of the March number include a reply to Dr. Sterry Hunt's views on Chemical Geology, by Mr. David Forbes; a descriptive paper on the Geology of Charnwood Forest, which possesses considerable additional interest on account of its having been written by the late Rev. Baden Powell; the conclusion of Mr. Carruthers's admirable revision of British Graptolites; and some other articles and translations of value.

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* Proceedings of the Royal Society, vol. xxiv., p. 736.

† "Quadrupeds" in the title.

‡ Vol. x., fasc. 2, p. 225.

In the April number, Mr. Carruthers describes some British Fossil, *Pandaneæ*, or "Screw Pines," from the Inferior and Great Oolite and the Potton Sands. This group of Pines at the present day inhabits the tropical and sub-tropical regions of the Old World. The other papers include a useful description of the Gault of Folkestone, by Mr. De Rance, and the commencement of a valuable account of the Fossil Insects of North America, by Mr. Scudder.

The last-mentioned paper is concluded in the May number, and from it we learn that 87 species of fossil insects have been discovered in North America. The *Diptera* (45), *Hemiptera* (6), *Hymenoptera* (3), and *Lepidoptera* (2), omitting one doubtful Carboniferous species, are restricted to the Tertiaries, as also are the *Coleoptera* (10), except one species from the Trias. The *Orthoptera* and *Neuroptera* (together numbering 18 species) are, the former Carboniferous, and the latter Carboniferous and Devonian, while the *Myriapoda* (2) are also Carboniferous.

Professor Huxley describes in the May number two new South African fossil reptiles, and there are several other articles of interest, especially one on Clacton, in Essex, by the Rev. Osmond Fisher.

PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

A large portion of the last 'Quarterly Journal' is occupied by the Annual Report and the Anniversary Address of the President (Mr. Warington W. Smyth). The latter includes notices of a variety of recent researches—especially on the origin of crystalline rocks, and on the geology of the Alps—and of the latest results of various geological surveys; but it is mainly occupied with discussions of three very interesting subjects, namely: (1) the physical structure of Palestine; (2) the climate of the earth's surface during past geological periods; and (3) the temperature of the earth's crust at great depths below the surface.

On the first subject we must draw attention to Mr. Smyth's able summing up of the arguments relating to the origin of the Dead Sea depression. So impartially does he weigh the evidence, and state the various conclusions which it has suggested, that it is difficult to ascertain his own convictions on the subject. It seems probable, however, that he favours the view suggested first by Hitchcock and adopted by Lartêt, "that a fault or dislocation takes its course along the line of the valley, having a heavy downthrow to the west, and that, in fact, the present depression was produced by a relative descent of the eastern side of the hill-district of Judæa during the movements that raised the entire land from the sea." The change in the surface-level of the Dead Sea, and the speculations on the causes which have contributed to lessen the volume of its waters, lead Mr. Smyth by an easy step to a discussion of the numerous facts which prove oscillations of climate during past geological periods, and to an examination of the theories which have been advanced in explanation of the phenomena of the Glacial Period in countries which now enjoy a comparatively warm climate; and of a sub-tropical climate in Miocene times in regions which lie within the frigid zone of the Recent period. Considerable attention is given by the President to the familiar theory of the Swiss geologists, that the comparatively shrunken condition of the existing glaciers is due to the hot blast (called the Föhn or Scirocco) which keeps the snows and glaciers in check at the present day having its origin in the African deserts, while during the Glacial period this wind did not prevail in consequence of the deserts having then been submerged. It has, however, been shown by Professor Dove that the great bulk of the winds which descend hot, and full of moisture, on the Alpine regions has ascended from land and ocean far to the west of Africa. The inconclusiveness of the Swiss theory has also been illustrated on other grounds by Sir Charles Lyell, who has, in this connection, called attention to the fact that the sea of the North African deserts continued to exist in Post-tertiary times.

The possession, during the Miocene period, of a sub-tropical climate by the region of North Greenland, between the parallels of 70° and 80° N., is even more difficult of solution, as at present it is generally allowed that changes in physical geography are, alone, insufficient to produce the effect, while the probable results of cosmical changes are at present but slightly understood by geologists.

With respect to subterranean temperatures, Mr. Smyth gives an interesting summary of the principal facts and opinions, and succeeds in producing the impression that all existing theories on the subject are somewhat premature; but he most happily describes the efforts, successes, and failures of geologists in comparing them to the incidents in a voyage of discovery. "The region we make for is one of vast extent; and we sail on various courses and in very different varieties of craft. Some of us push rapidly forward in fast clippers; others cleave their way slowly, and yet not always surely."

Of the papers contained in the 'Proceedings' of the Society, we must first notice that by Sir John Lubbock, "On the Parallel Roads of Glen Roy," in which the author objects to the commonly received opinion that these roads are the beaches, in the ordinary sense of the term, of an ancient lake or arm of the sea. Sir John regards the roads as having been formed by material which fell from the hill-side above the lake to lower levels beneath the water, until at the water-level a shelf was formed. He regards the loose material on the hill-side as lying at the angle of repose, so that all accessions would roll into the water and be arranged beneath it at the same angle. The width and slope of the roads would thus be dependent on each other, and would be determined by the depth to which the water was affected by waves. "In fact the lower level of the roads marks the lower edge of the disturbed water, just as their upper edge coincides with its upper edge. We thus see why the three shelves are so similar in size, and also why their width is least when their inclination is greatest."

Mr. Tylor's paper "On the Amiens Gravel" is an attempt to disprove the well-known conclusions of Mr. Prestwich respecting the relative age of Quaternary deposits, and the date and manner of the excavation of the valleys on the sides of which they rest. The Amiens gravel is selected for this paper because, probably, it yields a typical example, and one to which a large amount of attention has been drawn. Mr. Tylor's principal conclusions are, (1) that the surface of the chalk had assumed its present form prior to the deposition of any of the gravel or loess now seen resting upon it; and (2) that the Quaternary deposits indicate a Pluvial period, just as the Northern drift indicates a Glacial.

Dr. Nicholson's paper "On the Graptolites of the Skiddaw Series" is a contribution to descriptive Palæontology of a very useful kind, but, as recent criticisms appear to indicate, of somewhat debateable value.

The scope of the elaborate paper "On the Glacial and Post-glacial Structure of Lincolnshire and South-east Yorkshire," by Mr. Searles V. Wood, jun., and the Rev. J. L. Rome, is difficult to chronicle. It is a description of local phenomena, and an attempt to assign to them the causes by which they may conceivably have been produced. On two points, however, it possesses a more general interest, namely, (1) in the separation of the Boulder-clay of Hessle from the true Boulder-clay of the eastern counties, and from the purple clay which in the district under consideration overlies it, and in the determination of the younger age of the first-named deposit than the true Boulder-clay; and (2) in the assignment of the so-called "Bridlington Crag" to an horizon included within the limits of the "purple clay."

We are glad to learn from the Annual Report that the Society continues in a flourishing condition, no less than sixty-two new Fellows having been elected during last year, amongst the names of whom we notice those of Earl de Grey and Ripon, Mr. R. H. Scott, Director of the Meteorological Department of the Board of Trade, Mr. A. W. Franks, Keeper of the Antiquities in the British Museum, and Mr. W. Carruthers.

Mr. Warington Smyth has been succeeded as President by Professor Huxley.

9. METALLURGY AND MINING.

METALLURGY.

Mr. C. W. Siemens has recently communicated to the Chemical Society a paper "On the regenerative Gas-furnace as applied to the production of Steel." Although the question relates more strictly to chemistry, we refer to it in this place for the purpose of directing the attention of those who are at all interested in Metallurgy to the curious facts stated as to the power of tungsten in giving hardness to steel, and in enabling it to receive and retain the magnetic force. The regenerative gas-furnace was of course fully described, and its advantages in many processes especially pointed out.

Ever and anon the combination of wolfram with iron, or more correctly speaking of tungsten and iron, claims our attention. The following extracts from a report on its use in Germany, which has been published by A. Keiffenheim and Co., may be worthy of attention:—

The pulverized wolfram ore is weighed off for each raw iron charge in a quantity corresponding with the intrinsic percentage which it is thought desirable to allow. This quantity is mixed with one pound of powdered manganese, and half-a-pound of salt, and the mixture is put into bags.

The raw iron charge is smelted in the puddling-furnace, and after a strong heat begins to develop and ascend; the bags containing the alloy are to be pressed one after the other, and, at short intervals, into the liquid mass, and at the same time the puddler must quickly stir up the whole mass with the raker, in order that the alloy may be equally distributed throughout.

Such is the general description of the process. This wolfram iron is said to be remarkable for toughness and strength. If it be so, we shall soon hear more of it.

Large quantities of wolfram have been obtained from the Kit Hill and Drake Walls mines in the neighbourhood of Callington. At one time the combination of tin ore and wolfram was treated by a process patented by Mr. Oxland, but worked by M. Jacob at Drake Walls, and the tungsten, as tungstate of soda, preserved. The demand for tungsten falling off, this process has been abandoned. Experiments are now in progress at East Pool mine, near Redruth in Cornwall, for separating the wolfram from the tin, the worth of which it considerably lowers, and it is hoped that the value of tungsten as an alloy with iron or steel may render the results profitable.

A considerable improvement has been made in the extraction of sulphur from its ores in Italy. It has usually been sublimed by different, but in all cases by wasteful processes. The new process is as follows:—A vessel made of boiler plate, in the form of a truncated cone, is filled with the ore of sulphur. There is a grating at the bottom to prevent the ore from falling through into the receiver, and under this a strainer of sheet-iron pierced with small holes. Up the centre,—passing from top to bottom,—is a pipe communicating with a steam boiler, which pipe is perforated with small holes. The vessel containing the ore is carefully closed, the steam is turned on, and issuing from the perforated pipe, it finds its way amidst the ore. In the course of a short time the sulphur melts, becoming very liquid it flows through the grate and the strainer into the receiver, in which it is kept in a liquid state until all the ore in the vessel is exhausted; it is then run off into moulds.

An apparatus of this kind has been put up at the Elvetica Iron Works, and the saving in time—and therefore of money—is very great. The production of sulphur appears to be increased from 20 per cent.—the quantity obtained by the old processes—to 37½ per cent. by the new one.

One of the largest blast-furnaces in Europe was blown in recently at Ferry Hill, Durham. Two furnaces have been built, 105 feet in height, and 28 feet diameter, blown by four powerful blast-engines. The experiment appears to have been most successful; and if it continues to prove so, the problem of monster furnaces would appear to be solved.

The manufacture of the metal aluminium has entirely ceased in this country, the works which were established at Washington, near Newcastle-on-Tyne, having been stopped. Aluminium bronze is, however, still made in small quantities. The 'American Artizan' informs us of a new process for making this beautiful alloy, which offers some advantages over the original process. Mr. Evrard, to whom this new process is due, uses pig-iron containing aluminium: this is slowly heated to fusion, and copper is added to the melted mass. After the mixture has been well stirred together, it is allowed to cool very slowly, when the aluminium bronze settles at the bottom of the crucible, it being much denser than iron.

A similar process is said to have been adopted for the separation of silicium from iron, the affinity of copper for silicium being exceedingly energetic.

MINING.

About a year since the Peruvian Government sent out an expedition to explore the northern parts of that country, about the rivers Maranow and Morona, which are tributaries to the Amazon. A Government steamer was employed under the command of a Major Vargas. An official report has been recently issued. This shows that gold exists in great quantities in the region through which the expedition passed. It is affirmed that an Indian using the ordinary gold-washing bowl could gather several ounces in two or three hours. That gold exists in the alluvial deposits in these parts there is no doubt, but the quantity said to be obtained is open to many doubts.

Dr. Gustav Tschermak read before the Imperial Geological Institute a very complete account of the gold mines of Transylvania. It appears that the precious metal is found disseminated in almost imperceptible particles in the trachytic rocks in the environs of Falathna and D'Abrud Banya, where it is still worked by the most primitive methods. There are 300 families or partnerships, consisting each of three individuals or thereabouts. A thousand quintals of the rock yield about 8,500 grains of pale-yellow gold, which contain a little silver. The rolled *débris* of the crystalline rocks found in the valley of l'Aranyos is carefully washed, and yields about half an ounce of gold to 31,000 quintals of stuff. This gold is of a deeper colour and contains less silver. They also find gold in a peculiar freestone (*Carpathiques bocardes*), which is of a pale colour, like that found in the trachytes. The gold mines of Transylvania have been worked from the earliest historic times, yet they still furnish above 2,000 lbs. avoirdupoise annually.

Chevalier C. von Hauer, of the Austrian Geological Survey, thus describes the emery of Asia Minor :—There are four beds of emery known in Asia Minor, that of Scalanuova, worked by an English commercial house, which furnishes alone all the demands of the Liverpool market. That of Tira, worked by a Turk, abundant, but of inferior quality, having in two or three years sent to England from 40,000 to 50,000 quintals (2,240,000 to 2,800,000 kilogrammes); that of Djelat-Kaffé, only recently opened; and, lastly, that of Gamlik, in the neighbourhood of the sea of Marmora, still little known. The emery of Naxos, of which the Government reserves the monopoly, is supposed to be of a superior quality to any other. The emery beds of the province of Smyrna have not been geologically explored. All that we can say of it is, that this mineral is found in compact masses, above the granite, and is traversed here and there by veins of this rock. It is worked without method. The greatest part of the produce is sent to Liverpool as it comes out of the mine, to be prepared and reduced to the form of powder more or less fine. The analysis of the samples sent to the Imperial Geological Institute, has proved in a hundred parts to be—

Silica	27·6	
Alumina	59·0	71·0
Oxide of iron	12·0	
Water	0·7	

The quality of emery is improved in proportion to the larger quantity of alumina it contains, and the smaller quantity of silica. That of the first quality contains only from 2 to 9 per cent. of silica; that of Asia Minor contains between 60 and 77 per cent. of alumina, and between 6 and 33 per cent. of oxide of iron.

The Coal-field of Johusdorfk (*Styria*), which was acquired by the State in 1842, is worked for a bed of Tertiary coal, and opened lengthwise to the extent of 3,000 fathoms (5,688 kilomètres). It consists of 23 grants, on a surface of 288,805 square fathoms, and on an extent of 1,500 fathoms (2,644 kilomètres) in length, in the direction of the bed. The working is carried on partly by open workings and partly by pillars; the carelessness and want of method with which the ancient proprietors proceeded have caused considerable losses of coal by subterranean fires, whose ravages cannot be stopped, except by expensive means, which also interfere with the regular working. In each of the two principal shafts there is a steam engine of 20-horse power, used as much for the exhaustion of the water as for the extraction of coal. The annual production is about 460,000 quintals (a quintal equals 56 kilogrammes), of which 80 per cent. are consumed by the iron forges of the neighbourhood. The workings employ 250 workmen, lodged in houses belonging to the State, who are treated in a special infirmary in cases of illness or accident. In 1866 the treasury for mutual assistance possessed a sum of 30,000 florins. (M. A. Pallausch, '*Imperial Geological Institute*,' sitting of the 31st March, 1868.)

The Austrian Geological Survey—chiefly by M. Foetterle and M. von Hauer—have prepared a map of the coal-fields of the Austrian empire, which has many novelties in its construction. In addition to the ordinary geological colouring, the annual coal produce of each locality is indicated by differently coloured squares; and lines of the same colour traced along the lines of railway, canals, and navigable rivers show the distribution of the coal at a single glance.

The total annual production of coal in the Austrian empire is according to this, the most recent authority, 80,000,000 quintals, about 9,000,000 statute tons.

The boring-machine put into Tincroft Mine, near Camborne, Cornwall, by Mr. Dëhring, some two or three months since, is answering well. It is found to work economically, and, under the guidance of two ordinary miners, the end is driven with great facility and small cost. General Haupt's machine, which is a drilling-machine, is now adapted to mining and tunnelling with advantage; and one of those machines is employed in an open quarry, doing its work well and with economy. The legislature of Massachusetts have asked General Haupt to take charge of the Hosaic Tunnel. Mr. Lowe's boring-machine is reported on as doing good work in Australia. We have consequently three machines competing with each other, and proving their relative values under different circumstances. We hope to see those machines employed ere long in our mines, to relieve the miners from the most trying part of their labour.

10. MINERALOGY.

Is it desirable that the mineralogist should cast aside all those long-established formulæ by which he expresses the chemical composition of his mineral-species, and introduce in their stead a new set of formulæ, written in accordance with the advanced views of our modern chemists? Such is the question which Professor von Kobell discusses in a short but interesting paper "On Typical and Empirical Formulæ in Mineralogy."* *Typical* formulæ, we need hardly say, are those in which certain compounds (such as hydrochloric acid, water, and ammonia) are taken as general types, from which other bodies may be derived by replacing their constituents, according to definite laws, by other elements or by groups of elements called radicals. To illustrate the application of this type-theory to express the constitution of minerals, our author selects the double silicate of potash and alumina, called *leucite*. The composition of this species we are accustomed to represent by the following formula:

$$\text{KO, Si O}_2 + \text{Al}_2\text{ O}_3\text{, 3 Si O}_2.$$

But behold the aspect which our formula assumes when written on the type-theory:

$$\left.\begin{array}{l}\overset{\text{IV}}{\text{Si}}_4\\ \overset{\text{VI}}{\text{Al}}\\ \text{K}_2\end{array}\right\}\text{O}_{12}$$

It may be necessary to remind those of our readers who have not kept pace with the advance of modern chemistry, that such an expression simply means that the mineral in question may be regarded as formed on the water-type, and that the 24 atoms of hydrogen in 12 molecules of water (H_2O) have been replaced by 4 atoms of tetratomic silicon, 1 atom of hexatomic aluminium, and 2 atoms of monatomic potassium. But although this mode of representing the constitution of chemical compounds has been of eminent service in organic chemistry, it would seem, even from this single illustration, that it is by no means of equal value in mineral chemistry.

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* 'Journal für praktische Chemie,' 1868, p. 159.

From this consideration of typical formulæ, we turn to the second question discussed in Von Kobell's paper. At the present time the mineralogist endeavours to express the manner in which the constituent elements may be grouped together in any given mineral, by what is termed a *rational* formula. Many chemists, however, would have us confess our ignorance of this mode of grouping, and would simply write the elements side by side, without regard to the manner in which they may be associated: such formulæ are said to be *empirical*. Thus, the antimonial sulphide of lead called *plagionite*, has a rational formula, as follows:—$4\,Pb\,S + 3\,Sb\,S_3$; an expression which plainly shows that the mineral is composed of 4 molecules of galena and 3 of antimonite. The would-be innovator objects, however, to this theory, and gives us therefore an empirical formula written in this fashion: $Pb_4\,Sb_3\,S_{13}$.

From such examples as these, Von Kobell concludes that there is no necessity, at present, for supplanting our old-fashioned expressions either by typical or by empirical formulæ—a conclusion by no means distasteful to so conservative a creature as the mineralogist.

"Agates, I think, of all stones, confess most of their past history." Such are the words of Mr. Ruskin in his pleasing little work, 'The Ethics of the Dust;' and under this belief he has, of late, set himself the task of studying their history, and interpreting it to the readers of the 'Geological Magazine.'* In one paper he describes a group of agate-like structures which he calls "Dipartite Jaspers," and in a second communication notices the class of "Folded Agates," while he hints that other papers are forthcoming on "Mural Agates" and "Involute Agates." Certainly the most attractive features of these articles are the admirable tinted engravings by which they are illustrated.

It has always been a moot-point whether the peculiar markings observable in the so-called moss-agates and Mocha stones are truly of organic origin. As bearing upon this point, we call attention to a subject recently brought before the Chemical Society by Mr. W. C. Roberts.† Certain specimens of colloid silica prepared in Graham's dialyser, and evaporated in air, exhibited singular dendritic forms which, under the microscope, were found to consist of radiating fibres having a cellular structure. These were evidently low vegetable organisms developed from spores which were deposited from the atmosphere, since similar specimens dried *in vacuo* were destitute of such appearances. It is possible, then, that vegetable life may be developed in siliceous solutions during solidification.

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* 'Geological Magazine,' April, 1868, p. 156; May, p. 208.

† 'Chemical News,' April 10, 1868, p. 175; April 24, p. 195.

Mr. David Forbes has published the second part of his "Researches in British Mineralogy."* In this paper he describes the occurrence of a sulphide of iron and nickel—probably a nickelliferous pyrrhotine—near Inverary Castle, in Argyleshire, and also at the Craigmuir nickel-mine, near Inverary. Our author calls attention to the tendency of nickel to associate itself with pyrrhotine or magnetic pyrites; whilst the allied metal, cobalt, prefers association with the ordinary iron pyrites. The same paper contains a notice of an arsenio-sulphide of nickel, referred to the species *Gersdorffite*, also found in the Craigmuir nickel-mine. An abstract of both the first and second parts of Mr. Forbes's "Researches" will be found in the 'Geological Magazine.'†

The exceedingly rare arseniate of copper called *Cornwallite* has been lately examined by Professor Church, who shows that the mineral contains only two equivalents of combined water, instead of five, as hitherto supposed. Its amended formula is thus given,‡ using of course the new equivalents:—

$$Cu_3\,2\,As\,O_4,\;2\,Cu\,H_2\,O_2,\;aq.$$

At length mineralogists are beginning to recognize the value of the microscope as an aid in their investigations. Herr Zirkel, whose name must be familiar to every geologist in connection with his admirable 'Petrographie,' has recently laid before the German Geological Society his researches "On the Microscopic Structure of Leucite, and the Composition of Leucite-bearing Rocks."§ Many crystals of this mineral exhibit, on section, a number of included glass-like particles and acicular bodies, either accumulated in the centre or symmetrically distributed around the margin of the crystal. The use of polarized light reveals a beautiful system of alternate dark and light lines, bearing a relation to the micro-lamellar structure of the mineral.

In a paper on the Basaltic Rocks of the Lower Main Valley, Herr Hornstein describes a new mineral to be called *Nigrescite*.‖ It occurs in the anamesite of Steinheim near Hanau, and may possibly be only an altered form of olivine. Its composition is thus given:—

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* 'Philosophical Magazine,' No. 236, p. 171.

† May, 1868, p. 222.

‡ 'Chemical News,' April 10, p. 175.

§ 'Zeitschrift d. Deutsch. Geolog. Gesell.' Bd. xx., Hft. 1, p. 97.

‖ 'Zeitsch. d. Deutsch. Geol. Gesell.' Bd. xix., p. 342; 'Neues Jahrb. f. Mineralogie,' 1868, Heft 2, p. 202.

Silica	52·29
Alumina	5·14
Lime	2 59
Magnesia	18·11
Protoxide of iron	15·71
„ of manganese	0·23
Water	6·29
	100·36

Professor Hermann has again directed his attention to the study of the rare mineral *Columbite.*[*] He shows that the metal tantalium is present in this mineral in the state of tantalic acid ($Ta_2 O$), and may therefore be replaced by the corresponding acids of niobium and ilmenium. Hence he establishes for columbite the general formula, $RO, R_2 O_3$, where RO represents the protoxides of iron and manganese, whilst $R_2 O_3$ represents tantalic, niobic, and ilmenic acids.

The Swedish mineralogist, Igelström, describes a new species from the iron mines of Långban, in Wermland.[†] From the manner in which it is disseminated through the matrix, he proposes to call it *Kataspilite.* It may perhaps turn out to be an altered variety of cordierite, with which it agrees in crystalline form. Its composition will be seen from the following analysis:—

Silica	40·05
Alumina and peroxide of iron	28·95
Lime	7·43
Magnesia	8·20
Potash	6·90
Soda	5·25
Loss	3·22
	100·00

An elaborate study of the optical characters of the minerals Harmotome and Wöhlerite has led M. Des Cloiseaux to the conclusion that the crystalline forms of these species must be referred to the *oblique* system, and not to the rhombic system, as previously imagined.[‡]

Professor Rammelsberg has been engaged in investigating the chemical composition of prehnite, talc, steatite, and chlorite; but his researches are not of general interest.[§]

On the 30th January of the present year a remarkable shower of meteoric stones fell at Sielce and Gostkow, near Pultusk, in Poland. Several of these stones are now in the British Museum. Externally they are covered with a dull dark-coloured crust, whilst internally they exhibit a bluish-grey colour, somewhat resembling the well-known meteorites of L'Aigle, in France.[*]

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[*] 'Journ. f. prakt. Chemie,' 1868, p. 127.

[†] 'Neues Jahrb. f. Mineral,' 1868, Heft 2, p. 203.

[‡] 'Proc. Roy. Soc.,' vol. xvi., No. 101, p. 319; 'Phil. Mag.,' June, 1868, p. 461.

[§] 'Zeitschr. d. Deutsch. Geol. Gesell.,' Bd. xx., p. 79, 82.

In spite of the value and variety of our British minerals, we have hitherto been without any work treating specially of their geographical distribution. Mr. Hall has therefore rendered a service to our science by collecting and arranging the principal mineral localities in Britain, and publishing them in the shape of a 'Directory.'[†] The topographical portion of the work is preceded by an alphabetical list of our 246 British species and sub-species, showing the percentage composition of each. The localities are arranged under their respective counties, and when possible the geological position of each mineral is noticed. Nothing would be easier, were we so disposed, than to point out numerous omissions and errors; but we refrain from doing this, under the belief that it would be wrong to seek perfection in the first edition of a work of reference of this character.

The continuation of Kenngott's 'Forschungen,' noticed in the Chronicles of last quarter,[‡] has since been published in the shape of a bulky octavo,[§] and the compiler turns out to be Dr. Kenngott himself.

Dr. Schrauf, of Vienna, has lately given us the second volume of his elaborate work on Physical Mineralogy,[||] the earlier volume of which has already been noticed in this Journal.[¶]

Tridymite is the name which Vom Rath proposes for a new Mexican mineral which promises to become of considerable interest; but as only a short preliminary notice has yet been published, we defer our description until we are in possession of further details.[**]

11. PHYSICS.

After a long series of experiments, Baron von Liebig has finally adopted the following process for silvering glass for optical purposes. The solutions employed are:—I. One part of fused argentic nitrate dissolved in 10 of water; II. (*a*) Commercial nitric acid, free from chlorine, neutralized with ammonic sesquicarbonate, and diluted to sp. gr. 1·115; or (*b*) 242 gr. ammonic sulphate dissolved in 1,200 c.c. water (sp. gr. 1·105 to 1·106); III. Solution of sodic hydrate sp. gr. 1·050 prepared from sodic carbonate, free from chlorine; IV. 50 grm. white sugar candy dissolved in little water, 3·1 gr. tartaric acid added, the mixture kept boiling for one hour, and diluted to 500 c.c.; V. 2·857 gr. dry cupric tartrate, covered over with water, and solution of sodic hydrate gradually added till solution has taken place, and the volume made up to 500 c.c. These solutions are mixed in the following proportions:—1st, 14 vol. of I., 10 vol. of II., and 75 vol. of III., = 99 vol. of (A) silvering solution; 2nd, 1 vol. of IV., 1 vol. of V., and 8 vol. of water = 10 vol. of (B) reducing solution. The silvering mixture is then made by diluting 50 vol. of the silvering solution (A) with from 250 to 300 vol. of water, and adding 10 vol. of the reducing solution (B). If ammonic sulphate has been employed for solution (A), the liquid, after mixing the three ingredients, must be allowed to stand three days before being used; the clear liquor may then be drawn off.

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[*] 'Poggendorf's Annalen,' 1868, No. 2, p. 351; 'Geol. Mag.,' May, p. 248.

[†] 'The Mineralogist's Directory; or a Guide to the principal Mineral Localities in the United Kingdom of Great Britain and Ireland.' By Townsend M. Hall, F.G.S.. London: 1868. 8vo, pp. 168.

[‡] P. 256.

[§] 'Uebersicht der Resultate Mineralogischer Forschungen in den Jahren. 1862–65,' entworfen von Dr. Adolf Kenngott. Leipzig: 1868. 8vo, pp. 482.

[||] 'Lehrbuch der physikalischen Mineralogie,' von Dr. Albrecht Schrauf. II. Band. 'Lehrbuch der angewandten Physik der Krystalle.' Vienna; 1868. 8vo, pp. 426.

[¶] Quart. Journ. Sc., vol. iii., p. 293.

[**] 'Pogg. Ann.,' 1868, No. 3, p. 507; 'Geol. Mag.,' June, p. 281.

Professor Draper of New York, who has also paid great attention to this subject, recommends the following process as being very successful for silvering glass mirrors. He divides the process into five operations, *viz.* the cleaning of the glass, the preparation of the silvering solution, the warming of the glass, the process of silvering, and the polishing. (The description is for a 15½-inch mirror.) 1. Rub the glass plate thoroughly with aquafortis, and then wash it with plenty of water and set it on edge on filtering paper to dry; then cover it with a mixture of alcohol and prepared chalk, and rub it in succession with cotton flannel. 2. Dissolve 560 grains of Rochelle salt (tartrate of soda and potassa) in 2 or 3 ounces of water and filter; dissolve 800 grains of nitrate of silver in 4 ounces of water. Take an ounce of strong ammonia of commerce and add nitrate solution to it until a brown precipitate remains undissolved. Then add more ammonia and again nitrate of silver solution. This alternate addition is to be carefully continued until the silver solution is exhausted, when some of the brown precipitate should remain in suspension. Filter. Just before using, mix the Rochelle salt and add water enough to make 22 ounces. The vessel in which the silvering is to be performed should be a circular dish of ordinary tin plate, and coated with a mixture of equal parts of beeswax and rosin. At opposite ends of one diameter two narrow pieces of wood are cemented to keep the face of the mirror from the bottom of the vessel. 3. The glass is slightly warmed by putting it in a tub or other suitable vessel and pouring in tepid water to cover the glass; then hot water is gradually stirred in. 4. Carry the glass to the silvering vessel, into which the silvering solution has been poured, place the whole apparatus before the window, and keep up a slow rocking motion. Leave the mirror in the liquid twenty minutes or half-an-hour, and wash with plenty of water. 5. When the mirror is perfectly dry, take a piece of the softest buckskin, stuff it with cotton, and go gently over the whole silver surface to condense the silver. The best stroke is a motion in small circles; rub an hour. The thickness of the silver thus obtained is about 1-200,000th of an inch.

Dr. W. M. Watts, who has been occupied for some years in the spectral examination of the Bessemer flame, has collected together some of his most important results. The changes which take place in the spectrum from the commencement of the *blow* to its termination are extremely interesting. When the blast is first turned on, Dr. Watts says that nothing is seen but a continuous spectrum. In three or four minutes the sodium line appears flashing through the spectrum and then becoming continuously visible; gradually an immense number of lines become visible, some as fine bright lines, others as intensely dark bands; and these increase in intensity until the conclusion of the operation. The cessation of the removal of carbon from the iron is strikingly evidenced by the disappearance of nearly all the dark lines and most of the bright ones.

The spectrum is remarkable from the total absence of lines in the more refrangible portion; it extends scarcely beyond the solar line *b*.

The occurrence of *absorption*-lines in the Bessemer-spectrum is in itself extremely probable; and that this is the case appears almost proved by the great intensity of some of the dark lines of the spectrum. It was with this view that the investigation was commenced, with the expectation that the spectrum would prove to be a compound one, in which the lines of iron, carbon, or carbonic oxide, &c., would be found, some as bright lines, others reversed as dark absorption-bands. To a certain extent this anticipation has been verified; but the great mass of the lines, including the brightest in the whole spectrum, have not as yet been identified.

In dealing with a complicated spectrum like that of the Bessemer-flame, it is indispensable that the spectrum should be actually compared with each separate spectrum of the elements sought.

The coincidences observed were, however, but very few, and totally failed to explain the nature of the Bessemer-spectrum. The lines of the well-known carbon-spectrum do not occur at all, either as bright lines or as absorption-bands; nor was any coincidence observed between the lines of the Bessemer-spectrum and those of the carbonic-oxide vacuum tube.

The lines of lithium, sodium, and potassium are always seen, and are unmistakable. Three bright lines have been recognized as due to iron. The red band of hydrogen is seen as a black band, more prominent in wet weather.

After the charge of iron has been blown, it is run into the ladle, and a certain quantity of the highly carbonized *spiegeleisen* is run into it. The effect of the addition of the spiegeleisen is the production of a flame which is larger and stronger when the blow has been carried rather far. This flame occasionally gives the same spectrum as the ordinary Bessemer-flame; but more commonly a quite different spectrum is seen, which reminds one at first of the ordinary carbon-spectrum, but differs from it very remarkably.

In the carbon-spectrum each group of lines has its strongest member on the left (*i.e.* less refrangible), and fades gradually away towards the right hand: in the spectrum of the spiegel-flame the reverse is the case; each group has its brightest line most refrangible, and fades away into darkness on the least refracted side. A comparison of the drawing of the spectrum of the spiegel-flame with that of the Bessemer-flame will show that they really contain the same lines; but the general appearance of the spectrum is completely changed by alteration of the relative brightness of the lines. This was shown by direct comparison of the actual spectra.

Dr. Watts concludes his paper by saying:—There can be no doubt that the principal lines of the Bessemer-spectrum are due to carbon in some form or other. My own belief is that they are due to incandescent carbon-vapour. The experiments in which I am at present engaged have already shown the existence of *two* totally different spectra, each capable of considerable modification (consisting in the addition of new lines) corresponding to alterations in the temperature or mode of producing the spectrum, and each due to incandescent carbon. It is possible that the Bessemer-spectrum may prove to be a third spectrum of carbon, produced under different circumstances from those under which the ordinary carbon-spectrum is obtained; and the intensity of the dark bands is more probably due to contrast with the extreme brilliancy of the bright lines, than to their actual formation by absorption.

At one of the recent meetings of the Manchester Literary and Philosophical Society, Mr. Dancer made some remarks on crystals containing fluid. The author has examined a large number of crystals of various kinds, from the collections of friends; and has found fluid in quartz from South America, Norway, the Alps, Ireland, Snowdon, and the Isle of Man; and in fluor-spar from Derbyshire; this latter specimen contained a considerable quantity of fluid, which burst the crystal at 180° F. He suggests the employment of the microscope as a valuable assistance in detecting spurious from real gems; very few of the latter are perfect, and the flaws and cavities are so distinct in character from those which are so abundant generally in artificial gems that very little experience is sufficient for the purpose. This mode of testing, of course, is limited to transparent crystals, but might be employed when the usual methods are not practicable. At the conclusion of the meeting, crystals containing fluid were exhibited under the microscopes, and the expansion of the fluid by elevating the temperature of the crystal whilst under examination.

HEAT.—The intense heat of the voltaic arc has been utilized by M. Le Roux for increasing the amount of light emitted by the incandescent carbon poles. By placing the base of a cylinder of magnesia, about eight millimetres in diameter, at a little distance from the carbon points, so that the arc may just touch it, the magnesia acquires a degree of incandescence comparable to that part in the bordering carbon craters. At the same time the light acquires a remarkable degree of constancy.

M. P. Pellogio has described a contrivance by means of which the troublesome "bumping" peculiar to certain liquids when under distillation may be entirely prevented. It consists of a glass tube, as wide as practicable, inserted through the tubulus, and reaching nearly to the bottom of the retort, and having the upper end bent at a right angle, and drawn out to nearly capillary dimensions, thus establishing a communication between the outer air and the interior of the retort. With the help of this arrangement such liquids as methylic alcohol, sulphuric acid, petroleum residues, &c., distil as smoothly as alcohol or water.

A memoir on the physical properties and the calorific power of petroleum and mineral oils has been brought before the Academy of Sciences by M. Deville. The mineral oil was submitted to distillation in a copper alembic furnished with a long worm tube, and also with a thermometer. By means of this apparatus the amount of distillate passing over at various temperatures was estimated. The possible danger by explosion was measured by the proportion distilling below 140°. The same experimental fact represents as well the loss which must be sustained to remove the explosive property of the oil. Another danger is encountered when the oils are enclosed in air-tight vessels—explosion by dilation. The amount of space necessary to be left above a mineral oil is calculated from the co-efficient of dilation. The data M. Deville has obtained from each sample are drawn generally from the following determinations. Loss by heating to 100°, to 120°, and so on, by intervals of 20° up to 200°; this is expressed in percentages. Composition of the oil, *i.e.* percentages of carbon, hydrogen, and oxygen, obtained by combustion. Density at zero, and at 50°, and co-efficient of dilation. Composition and density of the oil obtained by distillation, and density of the residue. In some cases the specific heat has been determined, and the latent heat at the mean temperature. M. Deville's memoir contains tables giving an immense number of experimental results; it is, however, only a first memoir; more upon the subject will be brought before the Academy shortly. It may not be without interest to state that M. Deville has undertaken this research by command of the Emperor, to report upon the most advantageous arrangements to adopt for the economic and safe employment of mineral oils, with especial reference to its use in transports.

ELECTRICITY.—The fabrication of porous carbon, for electrical purposes, engages the attention of no inconsiderable number of persons in the present day; this kind of carbon is made most advantageously by the following process:—A mixture of wood charcoal and animal charcoal is ground to a coarse powder, mixed with sawdust, and dried at a steam heat; as soon as the material is dried, and while still warm, 20 per cent. of tar is added. When cold a certain amount of asphaltum is added, and the mass pressed into moulds. The proportions in which the ingredients are used vary according to the circumstances. The moulded objects are placed in boxes of sheet iron, and covered all over with a mixture of sand and charcoal; afterwards they are heated on the sole of a furnace. Gases which are disengaged during the operation are burnt in the furnace. The entire operation lasts about 24 hours. Careful attention is required during the calcination; the properties of the carbon depend, in a great measure, upon the management of this part of the process.

Some recent correspondence between the Trinity House and the Board of Trade shows that the electric light at Dungeness can now be worked by either of the two engines, so that no disturbance occurs when one requires repair. The services of the high-class engineers and firemen have been dispensed with, and the Elder Brethren have since been enabled to do that which the connection of the men with the trades union prevented—*viz.* to have their own ordinary keepers trained to drive the engines, as well as to attend to the lamps, a steady old experienced keeper being placed at the head of the establishment. The magneto-electric apparatus shown at the Paris Exhibition presented several improvements. The working by either of two machines showed that the power or the light can be duplicated in thick weather; and the engines were utilized for working the pumps of an air fog-trumpet. The electric light was compared with the flash of a first-order revolving oil apparatus belonging to the French authorities; and at fifteen miles distance the Trinity House engineer, Mr. Douglass, estimated the power of the fixed electric light at twice that of the flash of the oil light. The superiority of penetrating power of the electric light in fog was shaken by some experiments made by the Royal

Engineers, but it turned out that this result, so different from all other experience, arose from a settlement in the wood-work supporting the electric lens, causing the lens to be out of its proper position. Since the alterations made at Dungeness the light there has worked with great regularity and efficiency; and the Elder Brethren have proposed to place similar lights at the South Foreland, Lowestoft, and Souter Point. The Board of Trade approve of the extension of this mode of illumination to the South Foreland and Lowestoft, but at present suspend their decision respecting Souter Point. The Committee of Elder Brethren who attended at the Paris Exhibition say:—As far as the eye is a test, the power of the English fixed light was considerably in excess of the French, and when both machines were in use, and there was a good current, the fixed beam of the English light did not contrast unfavourably with the revolving one of the French, the flash of which is of great power. The contrast of the electric fixed light with the French first-order oil dioptric revolving light was very marked: indeed, the one may be said to put the other out. But the most beautiful feature of the electric was the extraordinary beam it gave. It shone night after night, large, steady, and lustrous as a planet, and you could see in the darkness a beam passing as far as the eye could see. From the tower, with the light at our back, it was very marked, and quite lit the hills round Paris. The whole horizon in the plane of the light showed the white beam, and at the distance of four miles it shone upon the windows of some houses, making them appear to be lit up. By extinguishing, and relighting quickly several times, this was very plain. Altogether the light was very remarkable, and the committee are glad to be able to report such an advance as the powers of the light show over that at Dungeness; indeed, the latter gives to the observer no conception of what the present one is, and it is satisfactory to know that the result of five years' work and observation, with imperfect and ill-arranged apparatus, has now borne such good fruit, and that as England was the first to test and adopt this adjunct to the sources of lighthouse illumination, so she still retains her superiority. It is due, however, to Mr. Holmes to say, that great as are the improvements already effected, he states that he is confident he can yet greatly increase the illuminating power before the present apparatus is re-erected at a permanent station.

The following telegraphic feat, the particulars of which are taken from the 'New York Journal of the Telegraph,' deserves record here. At an early hour on the morning of February 1st, the wires of the Western Union Telegraph Company from San Francisco to Plaister Cove, Cape Breton and the wires of the New York Newfoundland and London Telegraph Company from Plaister Cove to Heart's Content were connected, and a brisk conversation commenced between these two continental extremes. Compliments were then passed between San Francisco and Valentia, Ireland, when the latter announced that a message was just then being received from London direct. This was said at 7.20 a.m., Valentia time, Feb. 1. At 7.21 a.m., Valentia time, the London message was started from Valentia for San Francisco; passed through New York at 2.35 a.m., New York time; was received in San Francisco at 11.21 p.m., San Francisco time, Jan. 31, and was at once acknowledged—the whole process occupying two minutes actual time, and the distance traversed being about 14,000 miles! Immediately after the transmission of the message referred to, the operator at San Francisco sent an eighty-word message to Heart's Content in three minutes, which the operator at Heart's Content repeated back in two minutes and fifty seconds. Distance, about 5,000 miles.

12. ZOOLOGY—ANIMAL MORPHOLOGY AND PHYSIOLOGY.

(*Proceedings of the Zoological Society of London.*)

New Species of Ape.—It will be remembered that M. du Chaillu described a species of ape under the native name of *Nshiego Mbouvè*, though zoologists were unwilling to accept it as a novelty, referring it to a variety of a known species. Dr. Slack of Philadelphia, however, has described it, in a communication to the Academy of Natural Sciences of Philadelphia, as distinct from the Chimpanzee; and says that a fine skeleton of an adult has been for some time in the Academy's collection, and was until recently regarded as a chimpanzee. Duvernoy had previously decided in favour of its specific distinctiness. Dr. Slack's description is, "general colour black, sometimes grey in old age. Size, about equal to *Anthropopithecus niger*. Head, black and shining; chin of adult bearded. Ears, large, much larger than in the gorilla, though smaller than those of the chimpanzee. Inhabits the deep forests and table-lands of Equatorial Africa."

Acclimatization of Sparrows.—The sparrows introduced into Australia by the Acclimatization Society bid fair to become as great a nuisance as those of the south of England, which we hear of as being slaughtered by the thousand. The latest complaint against them is contained in a letter from the Rev. George Mackie of South Yarrow to the Melbourne Corporation, in which he complains of the excessive damage done to his fruit-trees in consequence of the depredations of sparrows and similar birds, and asks permission to use a gun against them.

Moa Skull.—A perfect Moa skull is said to have been found near Westport, near a prospector's claim on the Caledonian Lead, at a depth of 25 feet from the surface, and embedded in clay that had no appearance of ever having been disturbed. The men who discovered it are now engaged in excavations, in the hope of finding the remainder of the skeleton.

Disease in Grouse.—Dr. John Young, of Glasgow, has investigated this subject, and finds that nearly every bird he examined was affected with tape-worm, not, however, as the primary disease, but arising from peritoneal inflammation, which resulted in adhesion of the intestines and in perforation. He considered the disease as not arising from local causes, but from mal-nutrition, inducing an inherited cachectic condition, which predisposed the young to suffer from temporary influences. Mr. Gray attributed great influence to over-protection—the annihilation of its natural enemies having allowed a greater number of sickly birds to survive; and thus a weaker race had sprung up where formerly only strong birds prevailed. Man's interference thus disturbed the nice balance of nature, and the consequent evils followed.

The Fauna of Palestine.—The Rev. H. B. Tristram recently read a paper before the Royal Society upon the results of the Palestine Exploration, as regards the Fauna and Flora. An examination of the Fauna shows that it forms an extreme southern province of the Palæarctic region, impinging upon the Ethiopian closely, and more distantly upon the Indian. The mammals point to an earlier settlement than that made across the recent deserts; there is no Indian immigration, and *Hyrax Syriacus* is an exclusively Ethiopian type. The birds are numerous and very irregularly distributed, the Dead Sea basin being distinct and typical, sometimes Indian, generally Ethiopian, in character, with no less than twenty-seven peculiar species. Among reptiles there is less intrusion of Ethiopian types, and snakes in particular are more limited to the original locality of the individuals. River-fish are few in number but distinct. Most of the eighty-one species of land and fresh-water mollusca have no geographical significance; the fresh-water being more distinct than the pulmonifera, and indicating a very ancient separation from any adjacent district. Similar inferences are drawn from the Arachnida and insects, as well as the Rhizopod fauna, which is similar to that of the Indian Ocean. It is remarked that the peculiar fish of the Jordan date probably from the earliest period after the elevation of the land.

Theory of Birds' Nests.—In an interesting paper by Mr. Wallace, in the 'Journal of Travel,' he endeavours to prove that the exact mode of nidification of each species of bird is probably the result of a variety of causes, which have been continually inducing modification, in accordance with changed organic or physical conditions, *viz.* first, the structure of the species; and second, its environment. He further points out that these are correlative, the former cause depending upon the latter, and *not vice versâ*. Mr. Wallace lays it down as a rule, that when both sexes of birds are of strikingly gay and conspicuous colours, the nest is such as to conceal the sitting bird; while whenever there is a striking contrast of colours (the male being gay and conspicuous, the female dull and obscure), the nest is open and the sitting bird exposed to view. He gives many illustrations of this view, embracing almost every group of bright-coloured birds. Mr. Wallace says he was first led to see these relations by the study of protective resemblance or *mimicry* among insects, and points out that there is no incapacity in the female sex among birds to receive the same bright hues and strongly contrasted tints with which their partners are so often decorated, since whenever they are protected or concealed during incubation, they are so adorned: hence, he infers, that it is due to the absence of such concealment that gay and conspicuous tints are withheld, as in the Chatterers, Manakins, and Tanagers. A few anomalous facts supply a crucial test, *viz.* in cases where the males assist in incubation, or perform it altogether, in which case, as in the Grey Phalarope, the sexes, which are alike in winter, become reversed in colours in summer, the female instead of the male taking on a gay and nuptial plumage—while the male sits on the eggs, which are laid upon the bare ground.

A curious instance of misplacement, for want of sufficient specimens for examination, seems likely to be corrected, in the case of a bird (*Steatornis caripensis*), referred to the goat-suckers from outward resemblance, but which is known to feed on fruits so hard as to require a hammer to break them. Specimens have lately been received in spirits, and presented to the College of Surgeons and British Museum, which will be submitted to anatomical examination.

Sexes of Spiders.—Mr. Pickard-Cambridge remarks upon the numerical relations between the sexes of spiders. He says that in the extensive group Epëiridæ, comprising several genera, he has never seen an example of the male sex; nor in an examination of the Museums of Vienna, Milan, Berlin, Frankfort, and Leyden, could he meet with a specimen, though females occurred in them all. He supposes that the males of this group are exceedingly small compared to females, and probably overlooked by collectors—and probably they would look like little horny and more or less spiny *ticks*. In Nephila, which are giants of the spider race, the males are almost unknown, and when known are ridiculously disproportionate in size to the females. Some species of other families also present a striking disproportion in the relative size of the sexes.

The extraordinary sexual history of the spiders may account for this on Mr. Darwin's principle of *sexual selection*. Thus the smaller the male individuals, the more chance they would have of escaping the ferocity of the female by playing at hide and seek among her limbs and over her body in the mode M. Vinson describes. This selection would go on exercising its inevitable influence upon the size of the males until at length they became what in M. Vinson's instances they appear to be—mere parasites upon the female; the indefinite diminution of the male would only be checked by the natural requirement of a certain size for the fulfilment of the offices of impregnation.

Lithodomous Annelids.—Mr. Ray Lankester records some cases of Annelids of the genera Sabella and Leucodore which occurred in calcareous boulders, and points out the curious fact that none of the accompanying sand-stones, however indurated, nor the clay, were ever bored, the perforations being entirely confined to rocks of the same chemical composition, whether soft as chalk or dense as limestone. Having pointed out that there is no hard structure in these annelids which non-boring species do not possess, he concludes that the constant apposition of the tail of the annelid is the cause—and this is proved to be acid, for placed on blue litmus paper it gives a strong acid reaction in both species. It is not contended, however, that all cases of boring are due to chemical agency, for some, as the Pholas in gneiss, disprove the universality of this explanation.

Pearl Fishing.—Australian letters relate a discovery of considerable importance, *viz.* the existence of an extensive pearl-fishery on the north-west coast of Western Australia. The fishing-ground is described as stretching along the coast no less than a thousand miles. There had been upwards of sixty tons of pearls obtained up to December, and these were purchased on the spot at the rate of 100*l.* per ton. The banks at Perth will advance 100*l.* per ton, not including the inside pearls, which are valued at from 1*l.* to 20*l.* sterling each. About thirty men were then engaged in pearling.

Swarms of Locusts.—Fearful devastation has been caused in Algeria by millions of locusts, which in the latter days of April last darkened the air for hours together, destroying every green thing. The inhabitants by every means in their power endeavoured to divert them from their fields, and torrents of rain drowned myriads of them, besides those killed by boys; but the destroyed numbers were but as a drop in the bucket to those which remained. Sickness was expected to follow this plague from the abundance of their putrefying bodies.

Breeding of Queen Bees.—M. De Romestin, English chaplain at Baden, calls the attention of English bee-keepers to a most important discovery made by M. Köhler, a Protestant minister in Hesse. It is no less than the secret of directing the breeding of the bee, so that, as with our cattle, we may select the choicest male to be the father of the future stock. The discovery would appear to be almost too wonderful to be true, but its value and reality are vouched for by some of the leading bee-keepers in Germany. Mr. Woodbury, a Devonshire bee-keeper, says, "M. Köhler's process having been communicated to me, I can state that it is simple and perfectly feasible; it has moreover been tried by some of the leading apiarians in Germany, who have publicly testified to its success. The natural method of pairing seems to be intended as a provision against unions between drones and queens of the same stock, which would be brothers and sisters, and therefore in directing their union artificially this point must be kept in mind. If pure Ligurian stocks can be maintained, the black bee will probably become an extinct species in a domesticated condition.

PROCEEDINGS OF THE ZOOLOGICAL SOCIETY OF LONDON.

The condition of this flourishing Society was laid before the Annual Meeting in April last, by which it appeared that there were 2,702 members, and the income of the Society amounted to 25,041*l*. The ordinary expenses were 21,566*l*., and 4,652*l*. had been spent in new buildings or live animals. They have a reserve fund of 10,000*l*. The number of persons who had visited the gardens in the year was 556,214. The gardens contained 2,010 animals, *viz.* 531 quadrupeds, 1,320 birds, and 129 reptiles.

Every week new animals are acquired by the gardens of the Society, a weekly register of which will be found in the pages of Mr. Buckland's Journal, 'Land and Water.' Of course, the greater number of these are birds, among which a nightingale captured in the gardens figures, and which sings contentedly in the society of a hen which has lived through the winter. The Regent-bird of Australia (*Sericulus melinus*) has been brought, for the first time, to England, and is interesting from possessing bower-building habits in common with the Satin-bird and Bower-bird. Some of the magnificent Formosa pheasants (*Euplocamus Swinhoii*) have also been received. But perhaps the most popularly interesting animals are four ringed or marbled seals (*Phoca discolor*), which occupy the pond in the place of the curious Walrus which unfortunately died.

At the ordinary meetings of the Society the usual amount of interest has been exhibited. Perhaps the most important paper was one by Professor Huxley, on the classification and distribution of the birds belonging to his divisions, Alectoromorphæ and Heteromorphæ.* This elaborate paper treated of the homologies of the parts of the skeletons of birds. Professor Huxley's remarks led him to believe in the existence of closer affinity than had before been held in birds of opposite habits, and which were widely separated by most authors. For instance, he did not find any important difference between the skeletons of Crax and Talegalla. He dwelt much on the peculiarities of the sternum in birds as separating genera and families.

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* By the latter term the Professor proposed to designate the singular form Opisthocomus, which recent examination had convinced him must be arranged as a distinct group in the vicinity of the Alectoromorphæ.

Mr. H. Adams continues his researches among the shells of such places as Ceylon, Mauritius, Bourbon, and Seychelles; and Messrs. Sclater and Salvin continue their investigation of the birds of America. Mr. R. Brown read a paper "On the Fauna of Queensland." Dr. Baird described a new species of intestinal worm of the genus *Sclerostoma* from the stomach of the African elephant; and Mr. Blyth exhibiting a specimen of the Cretan goat, which he considered to be identical with the *Capra ægagrus* of Afghanistan, Mr. Busk took occasion to corroborate the identity, and to observe that he believed the species to be the ancestor of the domestic goat.

A very interesting paper was read by Mr. Bartlett upon the incubation of that singular bird, the Apteryx, or Kiwi Kiwi. It appears that a male bird having recently been introduced, the hitherto solitary female had paired, and it was hoped that young would have resulted. The female had previously produced eggs, but which were of course infertile. The birds, perfectly quiet by day, were heard to be active during the night, the male uttering the note *kiwi kiwi* from time to time, whence its native name. The female produced two eggs, and sat upon them, but with no result, as they did not appear to have been fecundated. Mr. Sclater stated that he considered two to be the normal number of eggs sat upon by the struthious birds.

THE PUBLIC HEALTH.

London.—After the reading of Mr. Rumsey's able address on "State Medicine," at the meeting of the British Medical Association in Dublin, a joint committee of that Association and the Social Science Association was formed, for the purpose of taking into consideration the best means of securing further sanitary legislation and, more especially, the revision and consolidation of existing sanitary laws. The committee has had several meetings, and an active correspondence has been carried on amongst its members. The result has been the publication of two separate documents, a "memorandum" and a "memorial," which have been submitted to Her Majesty's Government. On Friday, the 2nd May, a numerous deputation of members of parliament, members of the joint committee of the two Associations, and medical officers of health from various parts of the country formed a deputation to wait on the Duke of Marlborough, as President of Her Majesty's Privy Council, the Right Hon. the Earl of Devon, President of the Poor Law Board, and the Right Hon. Gathorne Hardy, the Home Secretary, for the purpose of urging the object of the memorial, which was to promote a better administration of the laws relating to registration, medico-legal inquiries, and the improvement of the public health.

If past experience had not demonstrated the almost utter hopelessness of pressing upon Government officials the necessity of amending the condition of our sanitary laws, it might have been hoped that the imposing demonstration that waited on the Government in May would have produced some impression.

Almost all sections of the medical profession and of the societies interested in sanitary matters were represented. The president elect of the British Medical Association, the president of the Medical Council of Great Britain, the late president (Sir Thomas Watson) of the College of Physicians were there. Dr. Rumsey, of Cheltenham, Dr. Farr, of the Registrar-General's Office, Dr. Guy, and Mr. Chadwick were there. The deputation was, in fact, a parliament, a body of men who thoroughly understood the great questions they were about to urge upon the Government, and who if representative institutions were in this country what they ought to be would not be suing to be heard, but would be placed in a position where they might legislate on the great subject they so thoroughly understand. The memorial of the deputation in the first place sets forth that the time has come when the imperial parliament ought to take seriously into its consideration the question of whether any of the crude mass of legislation of which they have been guilty for the last twenty-five years has been of any good at all; whether it has not "tended to defeat, in whole or in part," the object it has had in view. The memorial then speaks in detail of the deficiencies of certain departments of state action in relation to health matters, and begins with registration. It deprecates the present imperfect system of registering births and deaths, and speaks of the absence of any registration of still-births and disease. The next subject alluded to is the present imperfect method of working medico-legal inquiries, requiring the coroner to employ inefficient medical witnesses, and refusing him the aid of efficient and experienced experts in his inquiries, and thereby encouraging secret murders, especially poisoning. The memorial also speaks of the present system of dealing with medical evidence in courts of law as such that it "altogether prevents the discovery of truth, discredits scientific medicine, and is a fruitful source of perplexity and misconception to bench, bar, and jury."

The memorial then refers to the fact that in many of the large towns of the kingdom the death-rate is steadily increasing, and that, in spite of all our sanitary legislation, few towns have taken advantage of it; that in scarcely any of them have medical officers of health been appointed at all. It also draws attention to the fact that the amount actually disbursed under the present disjointed and very inefficient system would, if otherwise distributed—the districts and many of the duties being consolidated—go far to maintain a sufficient staff of specially trained and highly qualified district scientific officers with inspectorial functions. The memorial concludes:—

"For all these reasons, and for others set forth in the accompanying 'memorandum' (drawn up by Dr. Rumsey, and approved by the joint committee), we ask for a thorough, impartial, and comprehensive inquiry, by a royal commission, having power to visit, or to send sub-commissioners to visit, the large towns, and other districts of the country, to obtain information and evidence, and to report on:—

"1. The manner in which the cases and causes of sickness and of death are and should be inquired into and recorded in the United Kingdom.

"2. The manner in which coroners' inquests and other medico-legal inquiries are and ought to be conducted, having reference particularly to the methods of taking scientific evidence.

"3. The operation and administration of sanitary laws, with special reference to the manner in which scientific and medical advice and aid in the prevention of disease are and should be afforded; and also with special reference to the extent of the areas or districts most convenient for sanitary and medico-legal purposes.

"4. The sanitary organization, existing and required, including a complete account of the several authorities and officers. The education, selection, qualification, duties, powers, tenure, and remuneration of the said officers to be specially reported on.

"5. The revision and consolidation of the sanitary laws, having special reference to the increase of the efficiency of their administration both central and local.'

The speakers on the occasion were Dr. Acland, Mr. Chadwick, Mr. Michael (formerly a medical man, now a barrister), Dr. Sibson, Mr. Acland, M.P., Dr. Symonds, Dr. Stewart, and Dr. Rumsey. Most of the speakers urged upon the Duke of Marlborough the necessity of a Royal Commission. Dr. Symonds, of Bristol, late a president of the British Medical Association, urged the creation by the Government of a new order of medical men, who would give their undivided attention to sanitary matters and to questions of medical jurisprudence. He said, speaking of medical men as at present authorized, "they were chiefly educated for the care of the sick; and, in the practice of professional duties over some years, a great deal of the knowledge which they primarily possessed would be found to have slipped away from their memories when they were suddenly examined upon some particular point requiring minute investigation. Now the medical man, when called upon to give evidence in a court of law, had to do so on three different heads. He had to give evidence such as an ordinary witness would on points which would be within general observation; then he had to give evidence of matters which had come within his knowledge as a professional man; then he was called upon to speak as to circumstances of which he was supposed to possess a knowledge by an acquaintance with chemistry and natural science. But it must be stated that a man might have possessed a great amount of knowledge of chemistry and natural science at an earlier time of his life, without being able to prove his knowledge in a law-court; and he might be a most able practitioner, yet, when called upon to discharge the duties of a medical jurist, might show great shortcomings. Then medical men were differently qualified in different parts of the country, and while some were educated well, others were educated ill. Surely, under these circumstances, it was not right that men should have the administration of the sanitary laws with only a general professional knowledge. This was a most important point, for the people had the right to have the best and most efficient officers to be obtained. What was required in Lincolnshire was demanded in Lancashire, and it was not right that there should be any difference in the qualification of the men who were to administer these important laws either in the one place or the other. It seemed to those who attended there, that a new order of medical men should be called into existence, upon whom should devolve the consideration of all those questions, who should be able to advise and instruct in all matters of sanitary science, and who would be able to answer off-hand all points which might easily have passed from the mind of general practitioners. Such a new order of medical men, by their influence on the public, by the education of the public in the laws of health, would do a vast amount of good among all classes of Her Majesty's subjects."

The Duke of Marlborough listened attentively to all the speakers said, and having replied, concluded by saying, "Whether the information wanted could be obtained by a Commission or through the offices, was a matter of secondary consideration." The Duke was quite right; nothing but delays, vexations, and annoyance will attend either process. Why do not the sanitary reformers go to the public? For ourselves, we confess that we are heartily and indignantly tired of waiting on Government officials; it has never ended in anything but vague promises and disappointment. If sanitary legislation is to be ever more than a mere name, it must be done through the people. Their voice must be heard in the House of Commons, and six men in earnest about Sanitary Reform in the Lower House, would carry every object asked for by the memorial in six months.

In connection with the above deputation, we may mention that the 5th clause in Mr. Torrens' 'Artizans' and Labourers' Dwellings Bill,' appointing officers of health without medical qualifications, has led to the following resolution from the Joint Committee on State Medicine:—

"That the chairman and secretary of this Committee be instructed without delay to call the attention of Her Majesty's Ministers to the 5th clause of the 'Artizans' and Labourers' Dwellings Bill;' and to urge them to withhold their assent to that clause on the following grounds:—

"1. That it would increase the confusion already existing, by creating, under the title of 'officers of health,' an inferior, unqualified, and inefficient class of agents, whom it would be difficult to supersede.

"2. That it would leave the appointment, remuneration, and dismissal of the proposed officers of health unconditionally in the hands of the local authorities.

"3. That an inquiry is about to be asked for into the appointment and action of medical men in the public service, and that, until the results of such inquiry, if granted by Government, shall be known, it is highly inexpedient to legislate on the question of health officers.

"4. That a better agency than that proposed in the said clause already exists; namely, the district medical officers under the Poor Law, who, pending the appointment of medical officers of health duly qualified and properly protected in the exercise of their functions, might be employed in that capacity, and should receive additional remuneration for such services."

It has appeared good to Messrs. Dixon, Kennard, and Goldney, Members of the House of Commons, to propose a Bill to amend 'The Act for preventing the Adulteration of Articles of Food and Drink, 1860.' Whether the new powers to be given of fining and imprisoning persons who sell adulterated food, and which are also extended to drugs, will galvanize the old Act into life may be questionable. The effort, however, is a good one, and deserves to be encouraged. We miss from this Bill the authoritative declaration, "Thou shalt not commit adulteration." Like all other permissive Acts, it gives the impression that, provided the authorities do not appoint analysts, and do not analyze the food, it is a man's privilege to adulterate.

Another sanitary Bill has also been brought into Parliament by Messrs. Clive, Golding, Newton, and Wyld, entitled 'A Bill to make better Provision for facilitating and regulating the Supply of Pure Water in Cities, Towns, and Districts throughout the United Kingdom of Great Britain and Ireland.' The clauses of the Bill will give power to persons to require that every company supplying water to a district shall supply every house in that district, and also to persons to require that landlords require the said companies to supply all dwelling-houses and tenements occupied by human beings with water.

These Bills are undoubtedly efforts in the right direction, but they are a part of the everlasting tinkering that is going on about all our sanitary legislation. It is rotten and leaking in every direction, and nothing but a sound foundation will ever give it security or value.

SCOTLAND.—The 'Scotsman' newspaper has recently had a series of articles on the question, "Is the Rate of Mortality Increasing?" They were very ably written, and by a person who evidently has access to the freshest and most reliable information, and whose acquaintance with the sanitary literature of the last thirty years is both extensive and varied. Having read the articles in question, we can scarcely feel inclined to answer the author's question in the affirmative. It would be one of the greatest slurs that could possibly be cast upon the medical and sanitary science of the present day, if we were even to believe that the rate of mortality is increasing. It is certain that, so far as Scotland is concerned, there is much difficulty on the part of the authorities to abate those nuisances and insanitary arrangements which result in the production of epidemic disease, and necessarily in the production of a high death-rate. In Glasgow, for instance, there is perhaps one of the most completely organized staffs of Sanitary Officers that can be found in the United Kingdom, and yet epidemic disease and a high rate of mortality still continue to manifest their existence in the community. The staff in question consists of the principal Medical

Officer of Health, Professor W. T. Gairdner, and five district officers, all of whom are medical men, and have under them thoroughly experienced sanitary inspectors. Through the agency of this staff, together with the assistance of the police authorities and the officers of the various Parochial Boards, the provisions of the 'Public Health (Scotland) Act, 1867,' are now being gradually brought into operation.

If we look at the death-rate of Glasgow we do not find much to boast of, although there is certainly room to be hopeful. The following figures will show that there is some improvement in progress:—

Deaths in five weeks ending May 5,	1866	.. ..	1513
" " "	1867	.. ..	1304
" " "	1868	.. ..	1304

It is true that a marked difference is observable between the mortality in 1866 and that in 1867 during the corresponding five weeks; but 1867 and 1868 do not afford such a favourable contrast; still, as epidemic disease was much more prevalent in April, 1866, than in the corresponding five weeks of either of the following years, we must not be despondent, as the increase of the population must be taken into account. Taking the weekly death-rate for four weeks in March during three consecutive years, the following numbers crop out:—

Death-rate of four weeks, March,	1868	..	29, 31, 31, 29
" " "	1867	..	32, 33, 35, 34
" " "	1866	..	33, 35, 35, 30

No well-wisher of his country, however, can feel satisfied with the Glasgow death-rate remaining at 30, 31, and 32, while London —even where there are certainly many hot-beds of epidemic disease —as frequently shows a mortality not exceeding from 22 to 24 per 1,000 of the estimated population per annum. But the death-rate of Glasgow must of necessity remain high, so long as the present system of constructing the smallest dwelling-houses prevails. The chief epidemic disease of Glasgow is undoubtedly typhus fever, and in thousands of the lowest class of houses in the city just named the structural arrangements of the "flats," as they are called, are the very best for assisting most effectually to spread the germs of the disease. From the inside common stair there is almost invariably a lobby from which entrance is obtained to from four to ten or more houses of one or two small apartments. Inwards this lobby is a *cul-de-sac*; there is no through ventilation from front to back; and thus as the air of the lobby is common to the whole of the houses, a case of typhus occurring in any one of them is rarely a solitary one, unless isolation is immediately effected by removal of the patient, and this followed by the requisite purifying and disinfecting measures. That epidemic fever is really decreasing in Glasgow, and that the decrease has been in progress from the beginning of the present year, may be learnt from the following figures:—

	Jan.	Feb.	Mar.	Ap.
Fever cases reported at Sanitary Office	423	344	343	279
Fever deaths reported to Registrars	45	39	31	28

Cases of typhus fever do occur, and deaths in a certain ratio do result, and this state of affairs will continue more or less extensively until the present fever-dens are rooted out by the operations of the City Improvement schemes and the City Union Railway. In the interim, however, overcrowding in other parts of the city is the immediate result, owing to the fact that many people are, or soon will be, dispossessed of their houses, and others with improved sanitary arrangements are not yet forthcoming.

Without the active sympathy and co-operation of other members of the community, it is found in Glasgow that the labours of the sanitary staff are not sufficient to eradicate or materially lessen the amount of epidemic disease, by removing the causes which lead to it, and hence a movement has been commenced to form an association to be called "The Sanitary Benevolent Association of Glasgow," two of the objects of which are thus stated in the circular furnished us by the secretary:—

"1. The visitation by a non-official voluntary agency, with the co-operation and advice of the sanitary officers of all parts of the city, especially of those which appear to be subject to the extraordinary pressure of the causes of destitution, disease, and death.

"2. The use of moral influence and the diffusion of information tending to the improvement of the sanitary condition of the inhabitants in all dwellings within which the evils above mentioned have been observed to prevail; *e.g.* the prevention of overcrowding and the removal of external nuisances, with or without the aid of the authorities; the recommendation of internal ventilation, cleansing, &c., when required; and the promotion, generally, of a higher standard of comfort, decency, and personal cleanliness, and of the habits of self-respect, temperance, and economy, which tend to the physical well-being of the community."

Our readers will doubtless join us in wishing the utmost measure of success to this praiseworthy movement. If it can in any way permanently reduce the enormous death-rate of the city of Glasgow we may expect to learn that the example will be followed in other disease-haunted towns.

It may not be undesirable to mention that we have now a valuable ally in the work of disseminating sound views on the subject of Public Health, in 'The Poor Law Magazine,' a monthly journal published in Glasgow, and the property of "The Society of Inspectors of Poor of Scotland." The usefulness of the magazine has been very greatly increased of late by the introduction of a

Public Health feature, embracing both original papers and articles from other journals. We are glad to know that our own pages have contained matter deemed worthy to be extracted by the editor of 'The Poor Law Magazine.' The monthly reports by the Glasgow sanitary officers regularly appear in the magazine, and as they frequently contain valuable sanitary hints and suggestions, the magazine ought to be of much value among the medical officers and inspectors of poor attached to the various parochial boards throughout Scotland.

The Glasgow Sewage Association previously mentioned is practically non-existent just now, but we are informed that the committee of the association, together with the gentlemen who read papers at the various meetings, will soon be called upon to draw up a report on the most valuable points embraced in the papers, and affirm a number of general principles on the disposal and utilization of sewage, and submit them to the town council for experimental trial before any general and expensive scheme is entered upon for the drainage of Glasgow and the permanent purification of the Clyde, on whose banks that great city is built. We would seriously advise our Glasgow friends to avoid the rock on which the scheme of the Metropolitan Board of Works has broken; let them firmly resolve to have no such outlet and deposit on the Clyde as are now threatening to prove a gigantic nuisance at Barking Creek, on the Thames.

It is some satisfaction to know that in Aberdeen there is at least one professional man, Dr. Robert Beveridge, who is wrathfully in earnest in determining to cope with the hydra-headed monster typhus, which, during three winters successively, has asserted its presence and authority in the "granite city." That gentleman, from his professional position in Aberdeen, has observed many startling facts in connection with the three years' epidemic; from the facts observed he has deduced many valuable opinions; and the facts and opinions he has dared to publish to the world in a pamphlet * which now lies before us. Aberdeen is a comparatively small and healthy town. Its population in 1866 was probably about 76,000, and yet the number of cases of typhus reached the enormous total of 4,631, and of that number no fewer than 610 terminated fatally. One in every 16·2 of the population was attacked, which is equal to 6·17 per cent. In one district, however, embracing about 42,000 of the population, there was an average of one person attacked with typhus out of every 12·56 of the population. Dr. Beveridge probably understates the cost of the epidemic at 55,021*l.* 4*s.*, equal, in fact, to a tax upon the inhabitants of something over fifteen shillings per head. There are some persons so hard-headed and granite-hearted that they can only be spoken to on such a subject as this through the medium of "*£. s. d.*," and Dr. Beveridge has done well to speak to them in such unmistakable language as he adopts.

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* 'On the Statistics of the recent Epidemic of Typhus in Aberdeen, showing its probable Cause and Cost.' London: W. W. Head, Victoria Press, 1868.

Dr. Beveridge strongly believes that the probable cause of the epidemic lies not external to the houses, but within them, and says, if it can be shown that the theory of overcrowding as a cause will account for the phenomena presented by the disease, it would seem probable that this is the true explanation of its origin. Here is a brief summary of the facts which Dr. Beveridge's observation has elicited. The disease is most intense in cold weather; it attacks females more than males; it attacks young persons in greater proportion than the old; contagious, and more dangerous in old than in young, and in males than in females; then, as specialities, it attacks individuals, as a rule, but once; the attack lasts three weeks, and is most dangerous in the second week. He adopts the theory of overcrowding, and shows that the facts would support it most satisfactorily. The epidemic, fortunately, is now got under; at all events, the ravages of the disease are at present on a much smaller extent. We learn that the sanitary condition of the town is fair on the whole, although in many points it might be improved. The water supply is excellent and in abundance, the water being taken from the Dee, about twenty miles from the town. The drainage is being improved, and a general plan adopted; but whether that will thoroughly answer the end in view, remains to be seen. The population, which was nearly stationary from 1850 to 1860, chiefly from commercial disasters, seems now to be rapidly increasing, but it is doubtful if house accommodation is at all keeping pace with the increase of population. Overcrowding is too common in many situations. Efforts have been made to set going a scheme for procuring statistics regularly on the sanitary state of the town, but hitherto without success, as the people in the far north are only with difficulty got out of their old jog-trot. Through paltry petty jealousies and parsimonious efforts at saving, there is room to fear that a laudable attempt being made just now to start a fever hospital will break down, and the people will only arouse from their apathy and stolid indifference by a return of the epidemic, for which no preparations will be made.

The benefits accruing to a town from having an active and lynx-eyed inspector of nuisances are well seen in Perth. During the first quarter of this year a typhus epidemic broke out very suddenly, and, notwithstanding the general mildness of the weather, soon ran the death-rate above that for the corresponding period in the two preceding years; but it almost as suddenly disappeared, owing, it is believed, to the active exertions of the officer just named. He is not only indefatigable in getting the lanes and "closes" cleansed, but when a case of fever occurs he comes down upon it forthwith, and effects a removal and therefore isolation, and then takes active measures to clean and disinfect the infected house.

In the last number of the Journal we referred to the efforts being made in Edinburgh to improve the condition of the poor of that city. The report from which we quoted has since been issued, and its startling facts have so thoroughly enlisted the sympathies of many professional, and well-to-do people generally, that an association is now formed for having the poor systematically visited, so that proper remedial measures may be adopted to ensure the eradication of at least some of the physical, social, and moral evil which at present runs riot in many parts of the Old Town of Edinburgh. The Lord Provost and magistrates of Edinburgh are now so much roused that they are publicly advertising their intention to enforce the provisions of the 'Local Police Acts' and of the 'Public Health (Scotland) Act, 1867,' against overcrowding in dwelling-houses, and that they will exact the prescribed penalties in every case of conviction. It is to be hoped that they will thus succeed in their efforts to diminish preventable disease; and that they may induce capitalists to build houses in healthy localities and in accordance with the most advanced sanitary knowledge of the present day. The water-supply of the city is in the hands of a company, and is frequently complained of both as to quantity and quality. If disease is to be diminished by personal cleanliness among the people, they must be in a position to get plenty of good water always when it is wanted; and we are glad to notice that an active member of the town-council is now (June) about to bring up the whole subject of water-supply to the city and surrounding districts for full consideration. The town-council of Leith is also moving in the same direction. Although the last-mentioned town is, generally speaking, in a healthy state, and the death-rate under the average, still for the last two months there has been an epidemic of scarlet fever prevalent in many parts of the burgh; and it has been particularly fatal among the young. This state of things ought not to exist; and it is satisfactory to know that both the Medical Officer of Health and the Health Committee are energetically endeavouring to cope with it.

A considerable amount of good has been done in the town of Paisley by a Ladies' Sanitary Society, which has been in existence for several years. As the new Public Health Act is now in operation, the well-intended labours of the Society are in a great measure superseded by those of the public authorities; still the ladies who have hitherto been banded together in well-doing do not wish to cease in their well-doing, and they have wisely, we think, resolved on directing their future efforts chiefly to sanitary education, by the distribution of tracts, visitation classes, mothers' meetings, and lectures; they have also resolved that special attention should be given to the spread of information on the treatment of infancy, so that the foul stain underlying the high rate of infantile mortality (43 per cent.) may be removed by diminishing the death-rate.

If any town in Scotland has acquired a notoriety over the others for the fatality of its epidemic disease, that town is certainly Greenock. A recent epidemic of typhus in that town (population 43,894 in 1861) was so dreadfully fatal, that it carried away no fewer than five of the medical men, who were perhaps even too faithful to the call of duty. The risk incurred by medical practitioners in Greenock from typhus, has, for many years, been very great. Of those who are at present in the town, it is probable that one-half have at one time or another passed through the ordeal of typhus. The fact of the extraordinary mortality just referred to created an excitement in the town, which resulted in a proposal to erect a monument in memory of the medical men who were stricken in the strife in the combat with the disease. A site was got for the proposed monument, and a design was prepared by Sir J. Noel Paton, and the public gratitude towards the memory of those who were faithful in duty seemed there to have completely evaporated. Greenock is now in a somewhat improved sanitary condition; but the authorities of the town may thank Dr. James Wallace, and not themselves, for it. So far as we can learn, he even incurred very serious displeasure from the "powers that be," because he would not rest content with things as they were, and threatened to bring the power of the law to bear on those who should always be ready to enforce it for the public good.

Quarterly List of Publications received for Review.

1. Rambles of a Naturalist on the Shores and Waters of the China Sea: being Observations in Natural History during a Voyage to China, Formosa, Borneo, Singapore, &c., made in Her Majesty's vessels in 1866 and 1867. By Cuthbert Collingwood, M.A., M.B., Oxon, F.L.S. 450 pp. 8vo. 10 *Illustrations.* *John Murray.*
2. Elements of Chemistry: Theoretical and Practical. By William Allen Miller, M.D., LL.D., F.R.S. Part II., Inorganic Chemistry. Fourth Edition. 900 pp. 8vo. *Longmans & Co.*
3. A Treatise on the Metallurgy of Iron, containing Outlines of the History of Iron Manufacture, Methods of Assay, and Analyses of Iron Ores, Processes of Manufacture of Iron and Steel, &c. By H. Bauerman, F.G.S. 46 *Engravings on Wood.* 400 pp. Post 8vo. *Virtue & Co.*
4. First Lessons in Astronomy, in Question and Answer. Seventh Edition. 100 pp. 24mo. *Jackson, Walford, & Hodder.*
5. The Rudiments of Mineralogy: a Concise View of the General Properties of Minerals. By Alexander Ramsay, jun. 338 pp. Fcap. 8vo. *Virtue & Co.*
6. Reliquiæ Aquitanicæ. By Edouard Lartet and Henry Christy. Part V. *H. Baillière.*
7. Celestial Objects for Common Telescopes. By Rev. T. W. Webb, M.A., F.R.A.S. Second Edition. 330 pp. Post 8vo. *Longmans & Co.*
8. The Great Architect: His Plan of Salvation in the Temple of Dead Stones and Living Stones, God and Man. 180 pp. Crown 8vo. *Longmans & Co.*
9. A Dictionary of Chemistry and the Allied Branches of other Sciences. By Henry Watts, B.A., F.C.S. Assisted by Eminent Contributors. 5 vols. Demy 8vo. *Longmans & Co.*
10. Thoughts of a Physician: being a Second Series of Evening Thoughts. *John Van Voorst.*

11. On the Ventilation of Dwelling Houses, and the Utilization of Waste Heat from Fire-places. By Frederick Edwards, jun. *R. Hardwicke.*

12. A Treatise on the Action of Vis Inertiæ in the Ocean. By William Leighton Jordan, F.R.G.S. 12 *Plates.* 220 pp. Demy 8vo. *Longmans & Co.*

13. General Catalogue of Books. 1130 pp. *Quaritch.*

14. Education and Training, considered as a Subject for State Legislation; together with Suggestions for making a Compulsory Law both Efficient and Acceptable to the People. By a Physician. 110 pp. Demy 8vo. *John Churchill & Sons.*

15. Transactions of the Woolhope Naturalists' Field Club, 1867. 200 pp. Demy 8vo.

PAMPHLETS, PERIODICALS, AND PROCEEDINGS OF SOCIETIES.

Sketch of the Geology of Spitzbergen. By A. E. Nordenskiöld. 2 *Maps.* 55 pp. 8vo.

Lichenes Spitsbergenses. By Th. M. Fries. 53 pp. 4to.

On the Existence of Rocks containing Organic Substances in the Fundamental Gneiss of Sweden. By L. J. Igelström, A. E. Nordenskiöld and F. L. Ekman. 9 pp. 8vo.

Om Trias-och Juraförsteningar från Spetsbergen. Af G. Lindström. 3 *Plates.* 18 pp. 4to.

Förberedande Undersökningar rörande Utförbarheten af en Gradmätning på Spetsbergen. Af N. Dunér och A. E. Nordenskiöld. *Map.* 16 pp. 4to.

History of Induction: the American Claim to the Induction Coil and its Electrostatic Developments. *With Engravings.* 124 pp. 8vo. *From Washington, U.S.A.*

Index to Vol. I. to XI. of Observations on the Genus Unio, together with Description of New Species of the Family Unionidæ, and Descriptions of New Species of the Melanidæ, Paludinæ, Helicidæ, &c. By Isaac Lea, LL.D. 60 pp. Imp. 4to. *From the Author.*

India: a Review of England's Financial Relations therewith. By Robert Knight. 70 pp. 8vo.

Intercolonial Trade, our only Safeguard against Disunion. By R. G. Haliburton, M.A. 40 pp. 8vo.

Against the Theory of the Retarding Influence of Tidal Action on the Axial Motion of the Earth, and showing the true Source of Tidal Energy. By A. R. Molison. 20 pp. 8vo.

On Sub-aërial Denudation, and on Cliffs and Escarpments of the Chalk and the Lower Tertiary Beds. By William Whitaker, B.A., F.G.S., of the Geological Survey. 24 pp. 8vo.

On Geological Time and the probable Date of the Glacial and Upper Miocene Period. By James Croll, of the Geological Survey of Scotland.

Beetroot Sugar: Remarks upon the Advantages derivable from its Growth and Manufacture in the United Kingdom. By Arnold Baruchson. *Effingham Wilson.*

On Hœmodromometers. By W. Handsel Griffiths.

On certain Butterfly Scales characteristic of Sex. By T. W. Wonfor.

On the Cost of Cultivation and Returns for Land manured with Latrine Poudrette in the vicinity of Cawnpore during the year 1866–7. Official Report from R. Simson, Esq., Secretary to the Government of the N.W. Provinces.

Christianity and Modern Progress. By Rev. A. Raleigh, D.D. *Jackson, Walford, & Hodder.*

The Fifth Annual Report of the Coroner for the Central District of Middlesex. By Edwin Lankester, M.D., F.R.S. 30 pp. Royal 8vo.

Transactions and Proceedings of the Royal Society of Victoria. Part II. Vol. VIII.

The American Naturalist.

Vargasia. Boletin de la Sociedad de Ciencias Fisicas y Naturales de Caracas. Num. 1–3.

The London Student. *John Churchill & Sons.*

The Westminster Review.

The Geological Magazine.

Proceedings of the Royal Institution of Great Britain.
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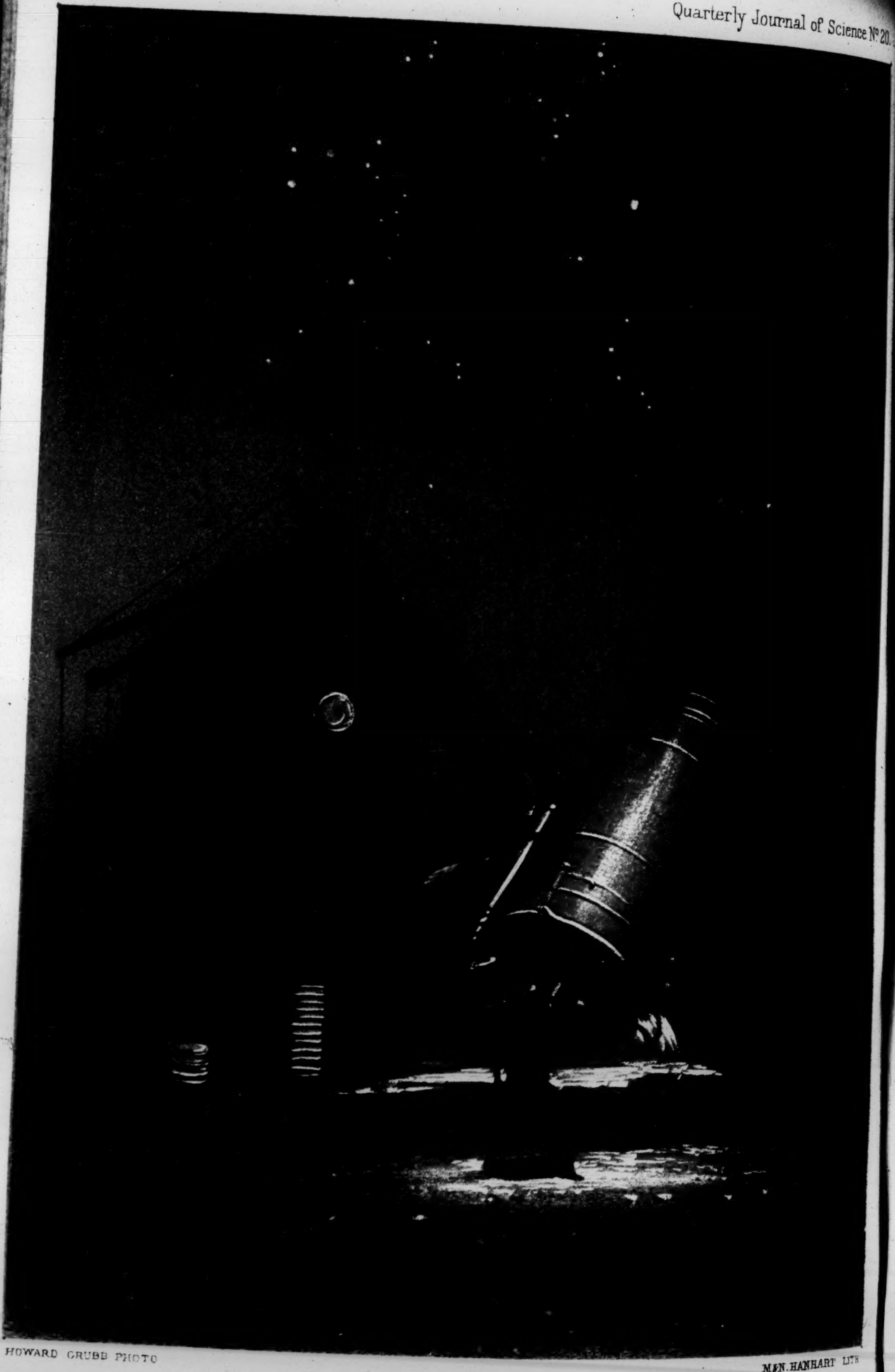

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